SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MARCH 1899.

GENERAL PHYSICS.

397. *Density of Ice.* **E. L. Nichols.** (Phys. Rev. 8. pp. 21–37, 1899.)—Four different kinds of ice were examined: Ice mantles produced by means of CO_2 and ether, natural ice in icicles, pond ice newly cut, and pond ice one year old. The natural ice was always found to be denser than the artificial ice, when both were quite clear and free from air-bubbles. The mean density of the former was 0·9182 at 0°, of the latter 0·9174.
E. E. F.

398. *Solution Densities.* **H. T. Barnes** and **A. P. Scott.** (Journ. Phys. Chem. 2, pp. 536–550, 1898.)—When a little zinc sulphate is added to water, no change in the volume of the water is observed until a density of about 1·150 is reached. After that, one molecule of zinc sulphate seems to displace one molecule of water. Experimenting with various sulphates, nitrates and chlorides, and also with sulphuric and hydrochloric acids, using a 10 c.c. pyknometer of Ostwald, the authors find that none of these solutions shows the flat part of the curve so strikingly as zinc sulphate. The molecule of salt seems to displace several molecules of water, but not less than one, and the density curve appears sometimes to start out to follow a one molecule relation, and then to bend into a two or three molecule relation or *vice versâ*. The authors consider the chemical analyses as the least reliable part of their work, but they do not appear to have purified their salts.
H. B.

399. *Density and Ductility.* **L. Grunmach.** (Wied. Annalen, 67. 1. pp. 227–232, 1899.)—A rod of Siemens-Martin flux

iron is turned in successive steps of lesser diameter, followed by successive steps of increasing diameter. In this shape the specimen is stretched until it breaks. The several steps are then cut asunder, and on determining their specific gravities it is found that that of the centre piece where the breaking took place is 0·5 per cent. less than that of the other pieces. E. E. F.

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400. *Capillary Angles.* **A. Rota.** (Roma R. Accad. Lincei Atti. 7. 2. pp. 125–129, 1898.)—The angle between alum and its saturated solution is 10° 16′ when the crystal is octahedral and the solution also such as to form octahedral crystals: 10° 22′ between a cubical crystal and a cube-crystal forming solution; 15° 36′ between a cube-crystal and an octahedron solution; and 15° 13′ between an octahedron and a cube solution. A. D.

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401. *Cohesion of Mercurial Columns.* **A. Pizzarello.** (N. Cimento, 8. 4. pp. 266–270, 1898.)—Columns of mercury more than 2·2 metres high can be sustained in glass tubes even against an external vacuum, by cohesion of the column and adhesion to the glass. A new piezometer is described. A. D.

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402. *Elasticity in Compound Pendulums.* **Helmert.** (Astron. Nachr. No. 3430 and Beitr. z. Theor. d. Reversionspendels, discussed by **P. Pizzetti** in N. Cimento, 8. 4. pp. 215–220, 1898.) —The corrections for elasticity are of such an order that they reduce an apparent length, in a particular case, of 994·626 mm. to one of 994·260 mm. The other sources of error are also carefully discussed. A. D.

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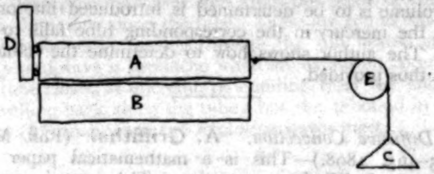
403. *Molecular Contact.* **J. S. Stevens.** (Phys. Rev. 8. pp. 49–53, 1899.)—In working with the interferometer, the author noticed that the brass plate which carries the movable mirror could be very slightly displaced along the bed upon which it lies, and that on releasing the pressure producing the displacement the fringes would return to their original position. To further study this effect, he measured the displacements for given weights applied to move the mirror-plate, using various metals for the two plates. In the accompanying diagram, D is the mirror fastened with wax on one end of the upper plate A. The displacement was produced by weights put into the scale-pan C, attached to A by a cord passing over the pulley E. The displacement ob-

served was nearly the same in brass, copper, iron, and steel, and amounted to three or four wave-lengths of sodium light. In the case of steel on steel it amounted to seven wave-lengths before sliding set in. The displacement is in every case nearly (probably exactly) proportional to the force applied. This holds for rough and smooth, for similar and dissimilar surfaces. It is evident that when the force applied is not sufficient to produce a complete rupture between the molecules in contact, an additional stress is set up, which brings about the return of the plate to its original position when the force is removed. E. E. F.



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404. *Mechanical Resistance of Air.* **O. Mannesmann.** (Wied. Annalen, 67. 1. pp. 105–131, 1899.)—The experiments are carried out by means of an improved rotation apparatus. A circular metallic plate is mounted on a horizontal arm and driven either by a water motor or an electromotor. It is capable of sliding forwards and backwards in the direction of motion, and in sliding backwards it pulls a cord leading to the centre of the axis of rotation, where a weight is attached to the cord. The amount by which the weight is lifted indicates the pressure on the plate, and this amount is shown on a large scale by an aluminium pointer. The author experimented on various plane and curved surfaces, the latter consisting of aluminium sheets "pressed" upon cast-iron spheres. He found that the resistance per unit of surface increased with the curvature in the case of concave surfaces, but that it was less than the normal amount in perforated surfaces —a fact which has a bearing upon sailing practice. With inclined planes, the maximum lifting effect (*Auftrieb*) is obtained at about 42° to the horizon. With slightly concave surfaces the angle is higher. The resistance increases with the temperature and the barometric pressure. When two plates are mounted one behind the other, their total resistance is less than double that of a single plate, but it becomes more than that when the distance apart attains a certain value. E. E. F.

405. *New Volumenometer.* **A. Oberbeck.** (Wied. Annalen, 67. 1. pp. 209–216, 1899.)—Two glass tubes provided with divided scales are fixed side by side on a board. At one end of the board they join, and are connected with a mercury reservoir. At the other end each tube is provided with an expansion in the shape of a beaker, which has a ground edge and can be closed air-tight. When this is done, and the board is inclined, the mercury falls by equal amounts along both tubes. But if the body whose volume is to be determined is introduced into one of the beakers, the mercury in the corresponding tube falls to a lesser extent. The author shows how to determine the volume from the data thus provided. E. E. F

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406. *Diffusive Convection.* **A. Griffiths.** (Phil. Mag. 46. pp. 453–465, 1898.)—This is a mathematical paper on the phenomena of diffusive convection. The case is considered of a vessel divided into two parts by a horizontal diaphragm through which two narrow tubes pass. The lower part of the vessel is filled with a solution of copper sulphate, the upper with pure water. While the tops of the two tubes are in the same horizontal plane in the water, one of the tubes descends to a lower level in the solution than the other. Under these circumstances, when things have attained a steady state, there will be a flow up the longer tube and down the shorter one. The author considers (1) the case of diffusion of a salt in a vertical tube through which the liquid is flowing with constant velocity, when the steady state has been attained; (2) the determination of the magnitude of the convection current in the case of tubes of equal bore, neglecting viscosity; (3) the effect of diffusive convection on the quantity of dissolved substance transmitted when the tubes are of equal bore and when they are of unequal bore; (4) the probable effect of viscosity on the convective flow; and finally describes an apparatus designed to illustrate experimentally diffusive velocity. The author is led to suggest that the heat produced on mixing a solution with water may depend on how the mixing takes place. Perhaps the matter may be connected with a sort of surface tension existing in the spaces between a strong and weak solution. J. J. S.

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407. *Equilibrium Figures.* **R. W. Wood.** (Phil. Mag. 46. pp. 162–164, 1898.)—Equilibrium figures (as in Meyer's floating magnets experiment) may be produced by dropping clean bicycle balls into clean mercury above a vertical electromagnet. In a larger group a larger ball ploughs its way to the centre. A. D.

408. *Pressure on Collision of two Explosion-waves.* **R. H. Jones and J. Bower.** (Mem. Manchester Lit. and Phil. Soc. 42. 7. pp. 1–7, 1897–8.)—An explosion-wave is partially checked by an imperfect junction in the apparatus, becomes less luminous, and does not recoup itself for some seven or eight inches. From the point of redetermination a back wave runs, and the tube almost invariably breaks at this point of redetermination. There is an actual increase of pressure on collision of two explosion-waves. Two rebound-waves start from the point of collision in opposite directions along the tube. These are sound-waves, made brightly luminous by passing through the still heated gases. A similar sound-wave is produced when an explosion takes place in a glass tube closed at one end, rebounding from the end surface and travelling back along the tube; but the rebound in this case is slower ($\frac{10}{13}$) than when two explosion-waves meet. A. D.

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409. *Propagation of Liquid Waves.* **G. Poisson.** (Comptes Rendus, 128. pp. 42–45, 1899.)—Under the assumptions that in any given form of watercourse the variations of section and slope only occur gradually, and that the longitudinal slope is so small that the angle is equal to its sine, the author shows how to calculate the maximum height of a wave in every part of the course and the corresponding speed. The waves need not be of infinitesimal height. E. E. F.

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410. *Longitudinal Waves.* **G. Bongiovanni.** (N. Cimento, 8. 4. pp. 61–66, 1898.)—A discussion of the use of a cylindrical spiral of wire to demonstrate stationary longitudinal waves and of the methods of ascertaining the contents of the spiral. A. D.

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411. *Muscular Elasticity.* **A. Chauveau.** (Comptes Rendus, 127. pp. 983–992, 1898.)—With the help of new registering apparatus, only referred to, in which the weights of the fore-arm and hand are counterpoised, and the tenacity of the muscle is neutralised, Chauveau has again studied the elastic force of the muscles. He distinguishes between the load p which a contracted muscle sustains and the load P, up to 2·5 kg. in his experiments, which produces a certain extension l of the muscle. In mechanics, $l=\frac{PL}{CS}$, where S is the sectional area, and C the co-efficient of elasticity resistance to extension. For the muscle, he finds $l=\frac{P}{p}$. The same load always produces the same extension, no matter which contraction we start from; and the same load is always required to make a certain additional contraction disappear. The curves are strikingly regular. H. B.

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412. *Muscular Action.* **Z. Treves.** (Torino R. Accad. Sci. Atti, 33. pp. 227–250, 1897–8.)—An overloaded muscle, rhythmically excited to contraction, gives oscillations of rapidly and greatly diminishing amplitude, and the muscle quickly becomes exhausted. When the stimulation and the load are such as to give the maximum work (weight × lift) the oscillations are constant in amplitude and the work remains constant for long periods of time; but these oscillations have a smaller amplitude than that of which the fresh muscle is capable with smaller loads. These smaller loads, however, give less work at each contraction. Under the condition of maximum work the subjective impression is one of a kind of unconsciousness of the work which is being done; this comes on after a preliminary feeling of fatigue. After a period of repose an overloaded muscle can again execute wider oscillations, again to fall off rapidly to small minima as before. Voluntary excitation of a muscle brings out higher values for the maximum work than electrical stimulation does. A. D.

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413. *Mechanical Illustration of Energy apparently Potential but really Kinetic.* **E. Merritt.** (Phys. Rev. 7. pp. 106–114, 1898.)—The employment of generalised co-ordinates makes it possible to discuss almost all branches of physics and show that they conform to mechanical principles, even when the details of the processes involved are not known. A difficulty sometimes arises, however, in attempts of this kind on account of the impossibility of distinguishing between potential and kinetic energy. In the case of the magnetic and electrostatic fields, for example, if we think of the field as being in a state of strain, the energy is regarded as potential; whereas if we consider the field as due to some condition of motion in the ether, its energy is properly regarded as kinetic. So long as we do not know what really goes on in the field, it is impossible to decide which of these two views is correct. In this case, as in many similar ones, it is possible to discuss the problem by the aid of generalised co-ordinates and to obtain correct results, no matter which hypothesis is made as to the character of the energy. The matter is much simplified, however, if the view be accepted that in reality all energy is kinetic, whether it be the energy of moving bodies of finite size or the energy of some motion whose existence can only be imagined.

According to this hypothesis, the energy due to a strained condition, such as that of a stretched spring, would in reality be the energy of some more or less complicated motion of the ether; this motion would be looked upon as the cause of the strain, and, in fact, as constituting the strained condition. If work is done against gravity in lifting a weight, it is usual to speak of this work as being stored in the form of potential energy; yet it is equally plausible to say that the work done in lifting the weight reappears as the kinetic energy of something analogous to eddies in the ether, these being brought into existence by the movement. This motion will continue as long as the body occupies its new position, and may be the cause of the force tending to make it fall. When the body is allowed to fall, the energy stored in this motion of the ether is given back again and appears as visible motion.

The author then passes to the mathematical discussion of a mechanical system, in general very complex, in which the energy is in reality all kinetic. The position of every particle being completely specified by the generalised co-ordinates ϕ_1, ϕ_2, the kinetic energy T is given by

$$T = f(\phi_1, \phi_2, \ldots, \dot{\phi}_1, \dot{\phi}_2, \ldots) \qquad (1)$$

where f is homogeneous and quadratic as regards the generalised velocities $\dot{\phi}_1, \dot{\phi}_2, \ldots$ If Φ_n is the generalised force acting to increase ϕ_n the equations of motion will take the form—

$$\frac{d}{dt}\frac{\partial T}{\partial \phi_n} - \frac{\partial T}{\partial \phi_n} = \Phi_n \qquad (2)$$

It is next assumed that the existence of certain essential co-ordinates is unknown to an observer who is studying the system in question. These unknown or concealed co-ordinates are denoted by $\psi_1, \psi_2, \ldots$ If certain restrictions are placed upon these co-ordinates and the motions corresponding to them, they may be made to explain the existence of apparent potential energy.

The necessary restrictions are: (1) That the concealed co-ordinates enter the expression for T only as velocities, *i.e.*, the $\dot{\psi}$'s appear in this expression, but not the ψ's themselves; (2) no outside forces act to change the concealed co-ordinates; (3) terms of the form $\dot{\phi}_m \dot{\psi}_n$ do not appear in the expression for T. When these assumptions are made the expression for the kinetic energy may be separated into two parts such that

$$T = f_1(\phi_1, \phi_2 \ldots \dot{\phi}_1, \dot{\phi}_2 \ldots) + f_2(\phi_1, \phi_2 \ldots \dot{\psi}_1, \dot{\psi}_2 \ldots) \qquad (3)$$

where f_1 contains only the known co-ordinates and their time derivations, while f_2 contains the known co-ordinates and the velocities of the concealed co-ordinates. Since no outside forces act to change the velocities of the concealed co-ordinates, the values of $\dot{\psi}_1, \dot{\psi}_2$, &c., will depend only upon the configuration of the system, *i.e.*, each of the $\dot{\psi}$'s is a function of the known co-ordinates only.

An observer ignorant of the existence of the concealed co-ordinates would naturally look upon f_2 as the expression for the *potential energy* of the system, for when the $\dot{\psi}$'s have been eliminated f_2 will appear to be a function of position only; f_1, on the other hand, being homogeneous and quadratic in the $\dot{\phi}$'s, would doubtless be accepted as the complete expression for the kinetic energy. This assumption of potential energy, when in reality none exists, would not merely be extremely plausible, but its incorrectness would also be difficult of proof; for all predictions based upon it regarding the behaviour of the system would be correct so far as they could be experimentally tested.

After further developing this general treatment, the paper concludes with the following concrete example:—

At each end of a rod of length $2r$ is mounted a mass m, whose dimensions are so small as compared to the length r that the mass may be looked upon as concentrated at a point. The rod is pivoted at the centre so as to be carried by the arm R in its rotation about the vertical shaft SS, to which, either directly or by means of a belt, is attached a heavy fly-wheel. The problem is further simplified if the inertia of this fly-wheel is so great that the angular velocity, ω, of the shaft will not be appreciably modified by any change in the position of the rod rr and its attached weights.

It is then shown on dynamical principles that, as the shaft SS rotates with angular velocity ω, the masses $m\ m'$ will vibrate about the horizontal position with period $2\pi/\omega$.

An observer of this motion is now supposed to be carried round with the arm R in its rotation, the conditions being such that he is not only ignorant of the mechanism of the apparatus that carries him, but is actually unaware of the fact that he is moving. Such an observer would notice that the system $m\ m'$ had a definite position of equilibrium, and that when displaced from this position a force tended to make it return. It would accordingly be most natural for him to assume that the system possessed potential energy when displaced, this energy being equal in amount to the work done during the displacement.

Following up this line of thought, it would be inferred that the system has, in addition to the kinetic energy $mr^2\,\dot{\theta}^2$, an amount of *potential* energy equal to $-mr^2\,\omega^2\cos^2\theta + \text{constant}$; whereas, what the system really possesses is the additional *kinetic* energy

$$+mr^2\,\omega^2\cos^2\theta + \text{constant}.$$

The opposite algebraical signs in the two cases apparently lead to a violation of the principle of the conservation of energy. The explanation lies in the term involving the moment of inertia K of the fly-wheel. If, as supposed, the variations in ω are small, it must be that K is large; hence the product $\frac{1}{2}\,K\,\omega^2$ will be subject to changes comparable in magnitude with the others under examination. It is thus shown finally that on the hypothesis of potential energy the term $-mr^2\,\omega^2\cos^2\theta + \text{constant}$ in reality takes the place of the two terms $\frac{1}{2}\,K\,\omega^2 + mr^2\,\omega^2\cos^2\theta$ in the energy expression, and that the value of the total energy remains unaltered, as it should, no matter which assumption is made regarding the distribution of energy between the two forms, kinetic and potential. E. H. B.

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414. *Forced Precession and Nutations of an Ellipsoidal Shell.* **W. McF. Orr.** (Phil. Mag. 46. pp. 545-553, 1898.)—The author calculates the difference between the precession and nutations of an oblate ellipsoid of revolution on the hypotheses of its being perfectly rigid and of its being filled with homogeneous incompressible liquid. He refers to results stated for the same problem by Kelvin, who, however, does not give the analyis. A A′ are the moments of inertia about an equatorial axis for the shell and liquid respectively, C C′ the corresponding moments about the axis of figure. The axes of the cavity are α, γ; m is the mass of the liquid, also

$$\mu=\tfrac{1}{5}m\,(\alpha^2-\gamma^2),\ \epsilon=(\alpha^2-\gamma^2)/(\alpha^2+\gamma^2)$$

If the axes of the disturbing couple turn relative to the shell with constant angular velocity κ in the same direction as the shell rotates, the component couples about the axes of x and y in the plane of the equator are the real parts of $\mathrm{L}e^{i\kappa t}$ and $\mathrm{M}e^{i\kappa t}$ where $\mathrm{L}=i\mathrm{M}$. Let n be the constant angular velocity round the polar axis, and let $\sigma=n+\kappa$.

In the notation of Routh's diagram let θ be the angle ZC, ψ the angle which ZC makes with ZX, ϕ the angle which CA makes with ZC produced. Also let α be the mean value of θ, ϕ_0 the mean value of ϕ. The author finds—

$$\theta=i\mathrm{M}e^{i(\sigma-\phi_0\cos\alpha)t}\Big/(n\mathrm{C}''-\sigma\mathrm{A}'')$$

where

$$n\mathrm{C}''-\sigma\mathrm{A}''=n\,(\mathrm{C}+\mathrm{C}')-\sigma\,(\mathrm{A}+\mathrm{A}')-(\mathrm{A}'-\mu\epsilon)\,\frac{\sigma(n-\sigma)}{\sigma+\epsilon n}$$

If the shell and liquid formed one rigid body, the denominator would be

$$n\,(\mathrm{C}+\mathrm{C}')-\sigma\,(\mathrm{A}+\mathrm{A}')$$

From which the result is calculated according as σ is positive or negative, and if negative according as $\sigma+n\epsilon$ is positive, zero, or negative. Kelvin, the author says, appears not to have taken into account the case of σ positive.

The result is applied to the case of the earth, but the author does not suggest that it has much practical interest. In effect he obtains results agreeing with those of Kelvin for precession and for the nineteen-yearly nutation, but differing for the half-yearly and fortnightly nutations.
S. H. B.

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415. *Earthquakes in Labuan.* **G. Agamennone.** (Roma R. Accad. Lincei Atti, 7. pp. 155-162, 1898.)—The paper refers to earthquakes which took place at Labuan on the 20th and 21st of September, 1897. The author tabulates the results, and works

out the velocities of propagation from the data of ten stations. The velocities of the more rapid waves vary between 17·71 and 27·71 km. per second in the case of the first; and between 16·13 and 29·29 in the case of the second. He attributes the cause of such differences to the varying degrees of sensitiveness of the different instruments, and would like to see more delicate instruments, such as those used in the Italian, and in European observatories, and of uniform design, whereby a greater uniformity of observation would be attained. Another source of inaccuracy being that as there were no observatories nearer the scene of action than Batavia, the times of this latter station were taken as identical with those at the seismic centre. He also finds that for the greater distances, if the chord be taken instead of the arc he obtains much greater approximations to what he considers correct results. A. Gs.

416. *Earthquake in Hayti.* **G. Agamennone.** (Roma R. Accad. Lincei Atti, 7. pp. 316–318, 1898.)—The author in this paper refers to an earthquake that occurred on Dec. 29th, 1897, in the valley of the Yaque river. The intensity of the shock was to the IX–X degree on the scale of *de Rossi-Forel;* the land influenced by the earthquake would not be less than 125,000 sq. kilometres (about 48,000 sq. miles). From the observations made at the observatory of Port au Prince the author concludes that the most rapid seismic waves are propagated with a mean velocity of 10 kilometres per sec. (6·2 miles). These waves were followed as usual by superficial undulations of slow period, having a mean velocity of 3 km. per sec. (1·86 mile).

The author considers that the Hayti earthquake proves his former assumptions, and gives a good support to his deductions in former papers. These are his most important conclusions from a very exhaustive study of the Hayti earthquake to be shortly published in the Bollettino della Società Sismologica Italiana. A. Gs.

LIGHT.

417. *Standards of Light.* **A. Blondel.** (Écl. Électr. 16. p. 317, 1898.)—The author has constructed a modified Hefner lamp of precisely the same power as the standard Hefner, in which a chimney is used so that the flame does not oscillate under a current of air, and in which either acetate of amyl or a mixture of absolute alcohol and crystallisable benzol may be employed. A. D.

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418. *Total Reflection.* **W. Voigt.** (Wied. Annalen, 67. 1. pp. 185–200, 1899.)—That even at "total reflection" some light penetrates the reflecting surface was proved by Newton by means of a third medium. The author attempts the same proof without that artifice, which, he maintains, impairs the strict validity of Newton's reasoning. He uses a prism whose base is an isosceles right-angled triangle. A line is drawn on the base from the middle of the hypotenuse to a point on one of the sides at a small distance from the end of the hypotenuse. Along this line a plane is cut parallel to the length of the prism. When light impinges upon the side surface in question, it is totally reflected by the hypotenuse and the new surface, but the junction of the two is indicated by a bright streak. E. E. F.

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419. *Orientation of the Slit in Interference Experiments.* **J. Walker.** (Phil. Mag. 46. pp. 553–557, 1898.)—This refers to a paper by the same author in the Phil. Mag. 46. pp. 472–478, 1898, and to some results obtained by Fabry. In the former paper it is shown that the relative retardation of the interfering streams from a point distant ξ from the central line of a properly orientated slit is measured in length $\alpha+\beta x+\gamma\xi$—the values of α, β, γ, being given in the present paper for the mirrors, for Fresnel's biprism, and for Billet's divided lens. The proper orientation of the slit is there defined. He now supposes the orientation of the slit to be varied by first turning it round its centre line through an angle ϕ, and then round the normal to its new plane through an angle θ, and calculates the visibility of the interference fringes in terms of ϕ and θ. The results are compared with those obtained by Fabry and Rayleigh. S. H. B.

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420. *Bright Bands produced by two Gratings.* **F. F. Martens.** (Zeitschr. Instrumentenk. Beibl. 16. p. 121, 1898.)—Parallel to each other in every way put two similar gratings on glass. Diffused light comes through these from a bright sheet

of white paper. The rays which come through clear glass areas in both gratings form groups, in each of which groups the rays are parallel to one another. Each such group is focussed by a lens so as to form a distinct band. Between these bands are dark areas, the light tending to reach which has been obstructed by one or other or both of the gratings. The eye on looking through the lens sees the further of the two gratings. The angular position of these bands is found to depend on the refractive index of the material between the grating surfaces, on their distance apart, and on the distances between the bars of the grating; whence an easy method of finding the refractive index of the glass on which the gratings are ruled. A. D.

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421. *Absorption of Light in a Magnetic Field.* **A. Righi.** (Comptes Rendus, 127. pp. 216–219, 1898.)—Assume a beam of white light to pass longitudinally along the axis of a Ruhmkorff electromagnet; polarise this by the first nicol, and let it be extinguished by the second. Between the poles is placed a sodium flame. As soon as the magnetic field is set up the flame will absorb radiations not of the same frequency as at first, but circularly polarised radiations of two frequencies respectively below and above the original frequency. This is the Zeeman phenomenon by absorption. Two residual circularly polarised radiations will thus reach the analyser; and one plane-polarised component of each will pass through. Accordingly there will not be extinction when the field is set up, but the passage of a yellow light resembling that absorbed by the sodium flame. These forecasts are confirmed by experiment. On turning the analyser the yellow light is not extinguished; it simply becomes whiter and brighter. A very strong original illumination will show this effect even with a magnetic field of 300 units, from one bichromate cell, lithium and thallium work as well as sodium, giving red and green light respectively. Hyponitric acid gas used instead of the sodium flame gives a green-blue, complementary, and with a complementary spectrum, to the yellow-red light transmitted by it; and on turning the analyser, the one colour changes into the other, without extinction, and the spectrum passes through a continuous condition into a complementary spectrum. This shows the emission spectrum of a non-luminous gas. Sodium vapour in hydrogen gas gives similar results. If the light pass exactly at right angles to the magnetic lines of force there is no effect. A. D.

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422. *Absorption in a Magnetic Field.* **A. Cotton.** (Comptes Rendus, 127. pp. 953–955, 1898.)—A beam of intense white light is made to traverse the following apparatus: (1) A nicol whose principal section makes an angle of 45° with the horizontal;

(2) an electromagnet giving a field of some thousands of units in which the lines of force are horizontal and exactly perpendicular to the beam; (3) a second nicol set almost at extinction with the first. The source is looked at across this nicol, and extinction is made complete. If a sodium flame of moderate brilliancy is now placed between the pole-pieces and the current started, the extinction is destroyed and a part of the original beam now traverses the second nicol; the source now sharply appears coloured yellow. On turning the second nicol through 45° so as to render its principal section vertical or horizontal, the same phenomenon is no longer observed: extinction once established persists when the field is set up.

This is an extension of an experiment of Righi, which was made in the same direction as the lines of force. The case is an application of the rule connecting together the emission and absorption for the same body, connecting the nature of the vibrations absorbed with the nature of the radiations emitted. When the beam is parallel to the lines of force, there is added to the phenomenon of Zeeman, which is a modification of the rays, Faraday's magnetic rotatory polarisation. This rotatory polarisation is particularly intense in the neighbourhood of the rays, as the experiments of Macaluso and Corbino show. It tends to destroy the original extinction. On making the experiment perpendicularly to the field its effects are removed, and those due to the Zeeman effect properly so-called are alone observed. J. J. S.

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423. *Zeeman Phenomenon.* **A. Righi.** (Roma R. Accad. Lincei Atti, 7. 1. pp. 295–301, 1898.)—Cornu has given an explanation (Journ. de Physique, Dec., 1897) which implies that for light emitted in the direction of the lines of magnetic force, every luminous ray becomes divided into two, circularly polarised in opposite senses, and that of these one has its period lengthened, one shortened, by the magnetic action. The difference between the Zeeman and the Faraday phenomenon would then be that in the former where the magnetic force acts on the luminous body, the velocity of propagation of the light remains unaffected though the period is changed: in the latter the period is unaffected but the velocities of propagation of the two components are altered. Airy showed that plane polarised light of N vibrations per second, passing through a Nicol's prism rotated n times per second round its own axis, may be considered as consisting of two opposite circularly polarised rays of frequencies, $N+n$ and $N-n$ respectively. Analogous results by other methods were described by the author in 1883 (Mem. R. Acc. Bologna, Jan. 14, 1883), and phenomena of interference between the two frequencies were also described at the same time, the fringes produced being not fixed but travelling athwart their length, after the manner of acoustical beats. It would be well if analogous experiments

could be made on the Zeeman light, but it appears not possible directly, since the two supposed rays come from natural light; but the following will show what conditions would be required to obtain the phenomena of beats. To represent natural light assume it to be elliptical, changing its form and axis rapidly, but yet slowly in comparison with the period of one complete vibration; in such a way that where $x=a\sin(2\pi Nt+\alpha)$ and $y=b\sin(2\pi Nt+\beta)$ represent the components at right angles to one another, we have the mean values of a^2 and b^2 equal to one another, and the analogous mean values of $ab\cos(\alpha+\beta)$ and of $ab\sin(a-\beta)$ both $=0$. Putting $A^2=a^2+b^2+2ab\sin(\beta-\alpha)$; $B^2=a^2+b^2-2ab\sin(\beta-\alpha)$; $\tan\phi=(a\sin\alpha-b\sin\beta)\div(a\cos\alpha+b\sin\beta)$; $\tan\psi\,(=a\sin\alpha+b\cos\beta)\div(a\cos\alpha-b\sin\beta)$; we get

$$x=\tfrac{1}{2}A\sin(2\pi Nt+\phi)+\tfrac{1}{2}B\sin(2\pi Nt+\psi)$$
$$y=\tfrac{1}{2}A\cos(2\pi Nt+\phi)-\tfrac{1}{2}B\cos(2\pi Nt+\psi)$$

of which the first terms in each represent a circularly polarised ray and the second terms an opposite one.

On Cornu's hypothesis we would have to substitute for N in these respective circular rays the experimental values N_1 (right-handed) and N_2 (left-handed): and there would be a difference of phase such that

$$\tan(\psi-\phi)=\frac{2ab\cos(\alpha-\beta)}{a^2-b^2}$$

As this difference of phase varies with the four terms, direct interference experiments are not possible through establishing differences of path. But suppose a biprism to divide the light into two paths, and a pair of quarter-plates, one on each path, with their principal sections at right angles to one another, to convert the two circular rays in each of the two halves into two plane-polarised rays; the respective plane-polarised rays of the same frequency in the two bundles being then polarised in planes parallel to one another in space. Then the two bundles would be brought through a nicol with its principal section parallel to one of the two orthogonal planes of polarisation; and nothing would remain but a plane-polarised ray of frequency N_1 and another parallel to it of frequency N_2. These could interfere with one another, provided not only is $(\psi-\varphi)$ constant, but also, as it turns out, that the mean values of a^2 and b^2 are not equal; that is that the light is not common light, but elliptically polarised light. And, further, the condition $(\psi-\phi)=const.$ itself implies circular polarisation, which becomes elliptical when the mean values of a^2 and b^2 are not equal; and to give zero intensities between the fringes the original light would have had to be plane-polarised. The experiment with shifting beat-fringes is therefore impossible with the light from Zeeman's tubes, but might be possible with the fluorescence light of certain crystals, which is said to be plane-polarised, though this light is probably considerably too weak for the purpose. The effect of the magnet in Zeeman's experiment is equivalent to the addition to the vibration of a uniform rotation, right-handed, of frequency n per second, where N_1 and N_2 are respectively N_0+n and N_0-n. Hence, rotating the luminous body fast enough ought to have a similar effect to that of magnetisation: and the sense of the equivalent rotation would be right-handed round an axis parallel to the lines of force. A suggested consequence of this is that merely passing the light through an analyser would show fluctuations whose frequency was n. The reason why the effect is equivalent to an added right-handed rotation is that if in the expressions $x=\frac{1}{2}\,A\sin(2\pi N_1t+\phi)$, $y=\frac{1}{2}\,A\cos(2\pi N_1t+\phi)$ for Cornu's right-handed ray and $x=\frac{1}{2}\,B\sin(2\pi N_2t+\psi)$, $y=-\frac{1}{2}\,B\cos(2\pi N_2t+\psi)$ for his left-handed ray we put the values for A, B, ϕ, and ψ given above and bring together the components on the same axes, we get

$$2x=a\sin(2\pi N_1t+\alpha)-b\cos(2\pi N_1t+\beta)+a\sin(2\pi N_2t+\alpha)+b\cos(2\pi N_2t+\beta),$$

$$2y=a\cos(2\pi N_1t+\alpha)+b\sin(2\pi N_1t+\beta)-a\cos(2\pi N_2t+\alpha)+b\sin(2\pi N_2t+\beta);$$

and on making $N_1=N_0+n$ and $N_2=N_0-n$ these transform into

$$x=b\cos(2\pi nt)\sin(2\pi N_0t+\alpha)+b\sin(2\pi nt)\sin(2\pi N_0t+\beta),$$

$$y=a\sin(2\pi nt)\sin(2\pi N_0t+\alpha+b\cos(2\pi nt)\sin(2\pi N_0t+\beta).$$

A. D.

424. *Inverse Zeeman Effect.* **A. Righi.** (Comptes Rendus, 128. pp. 45–48, 1899.)—The author does not agree with the opinion of Macaluso and Corbino that the rotation of the plane of the vibrations is the principal cause of the appearance of light in the inverse Zeeman effect, for the condition favourable for the observation of rotation (great breadth of absorption bands) is not necessary, and is even prejudicial to the observation of Righi's effect. One consequence of the great breadth of band is that the light which is made to appear by exciting the magnetic field is no longer complementary to the light transmitted by the absorbing body, and a change of colour is observed which indicates at once the existence of a Zeeman effect. Such a change of colour is well observed in a column of nitrous acid 40 cm. long, and in thin layers of bromine and iodine. In all the above experiments the light is supposed to be parallel to the magnetic lines of force.

E. E. F.

425. *Light Traversing Metallic Vapours in a Magnetic Field.* **D. Macaluso and O. M. Corbino.** (Comptes Rendus, 127. pp. 548–551, 1898.)—A beam of sunlight polarised by a nicol

traverses the magnetic field produced by an electromagnet, then a second nicol and a cylindrical lens; it is then received on a Rowland's concave grating. The second diffraction spectrum is observed. If between the poles of the unexcited electromagnet a Bünsen flame charged with sodium vapour is placed, the two absorption rays may by suitable arrangements be made to become very wide: thus D_2 may have a width equal to ¼ of the distance between the two rays. On now closing the circuit and producing a field of the intensity of 4,000 to 5,000 c.g.s. units, there is seen on each side of the two D rays bands parallel to the D lines, alternately luminous and obscure, which are displaced when the analyser is turned, the axis of each ray following the sense of the current.

These bands appear to be due to light polarised in different planes, and the primitive plane of polarisation has undergone, in the passage of the light across the sodium vapour influenced by the field, a rotation increasing in a continuous manner from the exterior to the margin of the ray. This rotation, which commences to manifest itself for the ray D_2 at a distance of more than two-thirds of that between the two rays, increases continuously and rapidly on approaching the edge of the ray, where it attains 270°. The relative rotation, *i.e.*, the difference of the rotations corresponding to equal displacements in the spectrum, increases rapidly in proportion as the edge of the ray is approached.

Proceeding in the spectrum from points farther off to points nearer the ray, the rotation of the corresponding planes of polarisation to the right and to the left of it occurs in the sense of the magnetising current, and consequently is reversed with inversion of the field.

At points at an equal distance to the right and to the left of the ray the rotations of the plane of polarisation are equal. For the two D rays the ratio of the distances at which equal rotations are produced is almost equal to the ratio of the breadths of the primitive rays. Whilst on the margin of each of the D rays the rotation is constant, the distance of the point where the rotation commences is greater in proportion as the ray is broader, so that with the widening of this latter the relative rotation diminishes and the bands become broader.

In the case of rays little widened on their edges, it is found that circularly polarised light occurs followed by elliptically polarised light, in which the ratio of the axes rapidly tends to zero. With the widening of the rays the circular light completely disappears and the elliptic remains confined to the margin of the ray, whilst the rotation of the plane of polarisation extends much beyond the margin. Similar but less pronounced effects have been found in the case of lithium vapour.

On the hypothesis that the two inverse circular rays, into which the original beam may be supposed to be decomposed, are propagated with different velocities in the vapours of sodium and lithium under the influence of the field, and that the difference of velocity diminishes rapidly with the increase of the difference between the period of the incident vibration and that of the absorbent value, the rotatory polarisation and the great rotatory dispersion observed may be explained. And on the hypothesis that for certain wave-lengths very little different from that of the ray, the absorbing power of the vapour for the two inverse circular rays may be different, the presence of circular and elliptic light on the edges of the ray may be explained. Both on the right and on the left of the ray the circular turning in the sense of the current would be propagated with a greater velocity, whilst on one side and on the other the circular in one sense and that in the opposite sense (conformably to the experiments of Zeeman) would be absorbed in preference.

(The explanation of the phenomena here described is discussed by M. Becquerel. See 1899, Abstract No. 246.) J. J. S.

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426. *Anomalous Dispersion and Magnetic Rotatory Power.* **H. Becquerel.** (Comptes Rendus, 127. pp. 899–904, 1898.) —Referring to his previous paper (see 1899, Abstract 246) the author describes the means which he has devised for verifying his hypothesis that the remarkably great rotatory power observed by Macaluso and Corbino in sodium vapour must be due to a phenomenon of anomalous dispersion. He has employed Kundt's arrangement, in which two prisms are crossed at right angles, one containing the absorbing substance. For this latter the author uses a flame containing the vapour of sodium or lithium and made to assume a prismatic form. Light from an electric arc is concentrated on a horizontal slit placed at the focus of a collimator; the parallel light then traverses the prismatic flame, then a lens, and afterwards forms an image of the slit at the vertical slit of a spectroscope with a Rowland's grating.

It is found that on each side of the rays D_1 and D_2 sodium vapour presents a very notable anomalous dispersion. The regions of the spectrum where the magnetic rotatory powers are many thousands of times greater than those of neighbouring portions, are equally the regions where the values of $\frac{dn}{d\lambda}$ become many thousands of times greater. It appears in accordance with the author's views previously expressed that the values of $\lambda \frac{dn}{d\lambda}$ give the relative values of the magnetic rotations for corresponding wave-lengths. J. J. S.

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427. *Metallic Vapours in a Magnetic Field.* **D. Macaluso** and **O. M. Corbino.** (Comptes Rendus, 127. pp. 951–953, 1898.)—The authors refer to their previous communication and Becquerel's paper on their experiments. (See 1899, Abstracts

Nos. 246 and 426). They criticise his theoretical explanation with regard to the expression $\lambda \frac{dn}{d\lambda}$ becoming infinitely great near the border of a ray of absorption. **H. Becquerel** maintains the explanation which he has given of the phenomenon, and thinks that the Italian authors do not appear to have an exact idea of the phenomenon of anomalous dispersion. J. J. S.

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428. *Magnetism and Gas Spectra.* **E. van Aubel.** (Journ. de Physique, 7. pp. 408–409, 1898.)—Spectra were obtained from a capillary-tube constriction in Geissler tubes, employing a large induction coil; the magnetic field was produced between cylindrical poles of an electromagnet with vertical bobbins carrying a current from 25 to 30 amperes. Chlorine (with a Leyden jar in circuit) shows the appearance of several new bright lines and the enfeeblement of others when the electromagnet was excited. Sulphur (with tube slightly heated beforehand) showed the band spectrum replaced by a brilliant line spectrum (and the Geissler tube, near the kathode, took up an apple-green fluorescence); much the same effect, as regards the change from bands to lines, as is produced by intercalating a Leyden jar in the circuit. Fluoride of silicon showed a complete change of the spectrum. The author attributes these effects to the influence of magnetisation on the electric resistance of the gas in the Geissler. A. D.

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429. *Röntgen Rays.* **G. Guglielmo.** (Roma R. Accad. Lincei Atti, 7. pp. 189–198, 1898.)—Discusses the molecular discharge and ether-displacement theories and concludes against the former for Röntgen rays, on the ground of the absorption being insufficient in amount. The want of diffraction and interference points to a want of periodicity. A. D.

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430. *Röntgen Ray Screens.* **P. Villard.** (Écl. Électr. 16. pp. 313–314, 1898.)—A barium platinocyanide screen, rendered non-responsive by prolonged exposure to Röntgen rays, may be revivified by exposure to sunlight. The ultra-violet, violet, and blue take hardly any part in this effect, the active rays in relation to which are three bands, respectively 900–710, 590–540, and 510–480 millionth mm. The third of these bands is the most effective. The first band is largely in the infra-red; the third hardly goes beyond the green. A. D.

431. *Transformations of Röntgen Rays.* **D. Hurmuzescu.** (Écl. Électr. 16. pp. 314–315, 1898.)—The discharging effect of the secondary rays produced on impact of Röntgen rays bears no relation to the opacity of the body impinged upon, nor to the nature of the surrounding gas; but it does depend on the material of the electroscope cage. A. D.

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432. *Medical Application of Röntgen Rays.* **A. Remond** and **Noë.** (Écl. Électr. 16. pp. 315–316, 1898.)—Excitation of the tube unipolar-wise by a static electric machine gets rid of the painful feeling associated with the exploration of cavities of the human body by a Crookes tube excited from an induction coil. Putting the positive terminal of the machine to earth, as also the patient, the operator, and all the instruments employed, keeps the patient's body all at zero potential, and there is no discomfort. A. D.

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433. *Radiography.* **O. Murani.** (N. Cimento, 8. 4. pp. 112–116, 1898.) — A metallic reflector is good when used immediately behind a photographic film; but it is of no use and is not required when a glass plate is used. In that case the glass itself acts as the reflector would do. **Malagoli** and **Bonacini** (ibid., pp. 97–102) say the metallic backing is necessary in all cases, even with glass plates, the more so the harder the tube, and especially so with focus-tubes; else there is fogging and want of contrasts. But it is less necessary with glass plates than with films; and with very soft pear-shaped Crookes tubes, which require long exposures, the advantage of using a metallic backing may disappear. A. D.

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434. *Röntgen Ray Shadows.* **E. Villari.** (Roma R. Accad. Lincei Atti, 7. 1. pp. 291–295, 1898.)—The shadow of a body which intercepts the radiations from a focus tube is bounded by a comparatively clear border some millimetres wide, a species of penumbra; this terminates abruptly exteriorly but degrades rapidly towards the centre of the shadow. If the tube used be a Crookes of pear shape, the shadow has a well-defined boundary. Near this boundary, within the shadow, is a black fringe; outside the boundary is a pale penumbra, fading away towards the exterior, some millimetres wide, which is followed by a very bright fringe, and this by the less bright region of full action of the rays upon the plate. The full central shadow seems to darken gradually from periphery to centre, by reason of a probable extensive flexion of the Röntgen rays in the umbral region between the intercepting body and the sensitive plate. A. D.

435. *Discharge by Röntgen Rays.* **E. Villari.** (Roma R. Accad. Lincei Atti, 7. pp. 261–272, 1898.)—Detailed experimental paper. The discharge of an electroscope by Röntgen rays is due to the air set in activity by these. An electroscope is thus discharged even in the full shadow of an obstacle, through the diffusion of this air. A tube of glass or zinc which suppresses laterally divergent rays slows down the discharge very much; and if the lateral active air be prevented from reaching the electroscope, again the discharge is slowed down; and the narrower the tube used the less is the discharging effect, because the smaller is the quantity of air rendered active. The discharge takes place though a protecting cover of aluminium or card be applied to the electroscope, as if the rays were bent round; but lead stops the action. On surrounding the ball of the electroscope with an insulated zinc tube, the effect of the Röntgen rays passed along the zinc tube is suddenly to discharge the outer induced charge on the zinc tube. This causes an apparent sudden partial discharge of the electroscope; and the gradual discharge by means of the air follows after this. The sudden apparent discharge can be imitated by discharging the outer induced charge by means of a flame. If the tube be of paraffin the opposite charge comes partly to the outside. If the paraffin be a solid block, there is no air, and the latter part of the phenomenon—the gradual discharge—is absent.

A. D.

436. *Röntgen Rays and High Temperatures.* **A. Volta.** (N. Cimento, 8. 4. pp. 241–255, 1898.)—A flame in the path of Röntgen rays does not appreciably affect their transmission, even in the presence of metallic vapours. Elevation of temperature increases, in platinum, steatite, and carbon, the actinic energy of their secondary radiations; especially in carbon, which, brought to incandescence, acts as an opaque body. For brass, zinc, tin, aluminium, microscopic cover-glasses, the penetration by secondary rays is not much affected by changes in temperature; but it is small, so that even thicknesses as small as 1 mm. will cause pretty complete absorption. The apparent transparence, as made out from the shadows, diminishes upon the heating; but this effect is small and sometimes uncertain. A. D.

437. *Duration of Röntgen Radiation.* **H. Morize.** (Comptes Rendus, 127. pp. 546–548, 1898.)—By a toothed-wheel method it is found that to each passage of current in the primary coil correspond several partial discharges in the tube. The total Röntgen radiation lasting 0·00109 second, each partial discharge takes 0·000082 sec., and the intervals between the partial discharges are all equal to 0·00033 sec. A. D.

438. *Fluorescence in Crookes Tubes.* **P. Villard.** (Écl. Électr. 16. p. 313, 1898.)—While the cross is forming its shadow in a Crookes tube, suddenly remove it from the path of the radiation. The place of the shadow is taken by a comparatively bright cross, which quickly disappears, leaving a uniform fluorescence. The shadow was comparatively cool and therefore more fluorescent than the glass already heated by the discharge; but the conditions soon become uniform. Direct experiments by local heating or cooling confirm this. Oxide of zinc fluoresces green when cold, violet when hot; sulphide of zinc, bluish and green respectively; chalk, orange to bright yellow. Perhaps glass which does not appear at all fluorescent when it is very hot, really gives out invisible radiations. A. D

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439. *Phosphorescence.* **H. Jackson.** (Phil. Mag. 46. pp. 402–414, 1898.)—This paper was given as a lecture at the British Association meeting at Bristol, and in it the attempt has been made to connect together all the phenomena of phosphorescence, with a view of showing between them a likeness in kind. It is suggested that all these phenomena may be looked upon as outward evidences of response on the part of the substances to rapid oscillations, whether these oscillations have their origin in chemical combination, in what is commonly spoken of as light, or in electrical discharge. The nature of that response may in some cases be of a direct character; but when account is taken of the many degrees of persistence of phosphorescence and of potential phosphorescence, it seems in many cases first to assume the form of something which may be called a statical charge. The release of this condition of strain is accompanied by oscillations which give rise to the visible undulations of the phosphorescent light. J. J. S.

HEAT.

440. *Thermal Conductivities of Glass.* **T. M. Focke.** (Wied. Annalen, 67. 1. pp. 132–159, 1899.)—The specific thermal conductivities of the ordinary constitutents of glass are tabulated as follows:—

MgO	$3{\cdot}71+10^3$	BaO	1·25	Na_2O	0·70
SiO_2	3·15	PCO	1·24	K_2O	0·59
Al_2O_3	2·58	ZnO	1·20	Sb_2O_3	0·28
S_2O_5	2·34	CaO	0·94	As_2O_5	13·1
B_2O_3	2·00				

When the conductivities of the various glasses are then determined from the weights of the constituents and the above values, the agreement is within 1·6 per cent. on the average.

The determinations of conductivities were made by Venske's method. E. E. F.

441. *Thermal Conductivities of Glass.* **A. Winkelmann.** (Wied. Annalen, 67. 1. pp. 160–164, 1899.)—The thermal conductivity of glass may be calculated from the volumes of the various chemical constitutents in the vitreous state, as known from their weights and densities. The author gives a method of doing this in which he supposes that the various constituents form separate layers of proportionate thickness, arranged in planes at right angles to the propagation of heat. This conception leads to a simple theory, and the calculated values agree with the observed ones, to within 5 per cent. at all events.

E. E. F.

442. *Linear Expansion.* **Vandevyver.** (Journ. de Physique, 7. pp. 409–414, 1898.)—Apparatus, based on the use of a spherometer, for measuring the thermal linear expansion of bars.

A. D.

443. *Temperatures in a Linear Bimetallic Conductor.* **P. Straneo.** (Roma R. Accad. Lincei Atti, 7. pp. 206–213, 1898.)—A mathematical investigation into the equations of condition during the variable state of the temperatures, in the most general case and also with superimposed limitations.

A. D.

SOUND.

444. *Vibrations of Plates.* **J. Zenneck.** (Wied. Annalen, 67. 1. pp. 165–184, 1899.)—The author endeavours to formulate a theory which includes the vibrations of such circular plates as are not perfectly symmetrical and homogeneous. He shows that of all the points in which any vibration could take place, those in which it actually does take place are distinguished in such a manner that for them the frequency is either a maximum or a minimum. E. E. F.

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445. *Vibrations of Pipes.* **A. Appunn.** (Wied. Annalen, 67. 1. pp. 217–221, 1899.)—Since the attacks made upon the accuracy of the pitches indicated on the author's standard pipes, he has verified these pitches by closing the pipes with small mica plates, which are stiff and elastic, and photographing the spot of light produced by these plates when they reflect a beam of sunlight. When analysed by a revolving mirror, the spot makes a series of dots and intervals expressing the vibrations of the air column. On counting the spots corresponding to a known interval of time, he found that the ratios had been indicated correctly, and that even the highest pitch, 56,000 per second, was correct to within a few hundred vibrations. E. E. F.

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446. *Difference Tones.* **A. Appunn.** (Wied. Annalen, 67. 1. pp. 222–226, 1899.)—In reply to the criticism of Melde and Stumpf and Meyer, the author maintains that difference tones cannot be successfully used to determine high pitches, on account of the great difficulty of distinguishing between the various orders of difference tones. Especially at the high pitches, the third difference tone is often the most audible. Thus in comparing a pipe having a pitch of 24,000 per second with one of 8,000 per second, the difference tones are 16,000 and 8,000 respectively. The latter being the stronger, the pitch is found to be 8,000 + 8,000 = 16,000, instead of 24,000. In case of the pipe of pitch 50,000, the same method also gives 16,000, as 8,000 is the pitch of the third difference tone, and is the loudest of the three. E. E. F.

ELECTRICITY.

447. *Wimshurst Machines.* **S. Leduc.** (Écl. Électr. 16. pp. 309–311, 1898.)—These machines work even without points, but the glow, as seen in the dark, is differently distributed. The starting-point is a contact E.M.F. between a metallic sector and the brush; and the opposed brushes form a condenser, the dielectric in which is the two plates and the space between them. Much of the charge on the metallic sectors is lost by discharge into the air before reaching the collectors; and the efficiency can be increased by adjusting the collectors so that they collect the charges on the metallic sectors immediately these charges become free through the withdrawal of the opposite sectors. A. D.

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448. *Adjustable Leyden Jars.* **S. Leduc.** (Écl. Électr. 16. pp. 311–312, 1898.)—The author makes the inner coating a metal-surfaced cylinder with hemispherical ends which can slide up and down. The outer coating covers only the lower part of the jar. Such Leyden jars are suitable for the author's method of exciting a Röntgen ray tube by fitting it between the outer coatings of two Leyden jars suspended on the two terminals of a frictional electric machine, the kathode being connected with the jar suspended on the positive terminal; a shunt being provided by means of a chain from each outer coating, with its free end lying on a board. The objection to this method, that the discharges are intermittent, is removed by sufficiently reducing the capacity of the Leyden jars; and if these adjustable Leyden jars are used, the tube should be connected with the movable inner coatings so as to avoid sparks. With Leduc's modified Wimshurst collectors and these Leyden jars a 22 to 24-inch Wimshurst gives results equivalent to those of a 6 to 8-inch spark induction coil, and the tubes are better treated under this method. A. D.

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449. *Electricity and Fog.* **A. Garbasso.** (N. Cimento, 8. 4. p. 265, 1898.)—The fog-dispersing effect of an electric charge is due to the charged surface rather than to the field; for if the former be covered with a glass tube, even though this be pierced with extremely small holes, there is no effect. A. D.

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450. *Velocity of Particles in Discharge by Ultra-violet Light.* **H. Buisson.** (Comptes Rendus, 127. pp. 224–226, 1898.)—The uniform potential slope between the plates of a condenser is disturbed by ultra-violet light, which produces a discharge of the

condenser; there is during the discharge free electricity in the air, the density is not null, nor ΔV, which becomes $\partial^2 V/\partial x^2$, and the potential line is a curve, nearly parabolic. The positive plate loses no charge: the charge of the negative plate is carried over to it. The air does not take any active part in the discharge. The density is found from $\partial^2 V/\partial x^2 = -4\pi\rho$ and the velocity v of the charged particles under density ρ, transversing section s of flux, and current strength i, from $i = v\rho s$. Integrating the former we get $V = V_1 x + 2\pi\rho x\,(d-x)$, of which the latter term can easily be measured differentially and ρ found. This gives v. The velocity v is independent of the intensity of the light employed, and is approximately proportional to the field: 25 cm./sec. at 10 volts/cm., and 135 cm./sec. at 60 volts/cm. Righi found higher velocities, but he used powerful fields from an electrostatic machine, about 30,000 volts apparently. A. D.

451. *Electric Sparks.* **S. Leduc.** (Écl. Électr. 16. pp. 312–313, 1898.)—Taking sparks between a sphere brought into contact with the film side of a photographic plate, and a tinfoil backing, the image on development is very sharply defined, without fog, and differs according to the direction; and the spark area is broadened by increase of potential, but narrowed by increase of quantity. As the air-pressure is diminished the image becomes more and more blurred, and at 1 to 2 cm. Hg there is complete fogging. The spark image is different in different gases. In alcohol (covered by CO_2 gas) there is no luminous effect, but the plate is fogged. Dusting the plate with various substances alters the result and makes the differences smaller between positive and negative discharges. When both terminals are brought into contact with the same photographic film, the image of the discharge is different at its two ends, which points away from the idea that the transport of matter is in one direction only. A. D.

452. *Point-Discharges.* **E. Warburg.** (Berlin Akad. Sitzber. 17. pp. 236–242, 1898.)—When a point is placed opposite a metallic surface which is connected through a galvanometer to earth, and the point brought to a potential which exceeds a certain limit, the galvanometer indicates a constant current, which is carried from the point to the metallic surface by the intervening air. The air has thus acquired conductivity; and the author finds that it fully acquires this conductivity in 0·007 second after the point has been charged. Probably, though not yet certainly, this is a true conductivity of the whole air between the point and the plate, and the electric wind is a secondary phenomenon. A. D.

453. *Point-Discharges.* **E. Warburg.** (Wied. Annalen, 67. 1. pp. 69–83, 1899.)—If a point P is kept in a constant absolute potential V, and is mounted opposite an infinite metallic plane at a distance D, the density of the current traversing the air between the point and the plate is at any point Q—

$$i=\frac{a}{D^n}V\,(V-M)\cos^m\theta$$

where $\theta < 60°$, and denotes the angle between P Q and the normal, while a and M are positive constants depending upon the nature of the point, $n=3{\cdot}17$, and $m=4{\cdot}65$ for negative potentials and 4·82 for positive potentials. E. E. F.

454. *Kathode Rays.* **P. Villard.** (Comptes Rendus, 127. pp. 223–224, 1898.)—A paper upon the fluorescence observed in a focus tube and attributed by S. P. Thompson to *parakathode* rays from the point of impact of the kathode rays, sensitive to electric and magnetic fields, but not capable of originating Röntgen rays. The author holds they do produce Röntgen rays, and are genuine kathode rays which may be provisionally considered as arising from diffusion of the primary kathode rays—diffusion which presents a maximum of intensity in a direction not very different from that which would be taken by regularly reflected rays. The result is the same whether the antikathode be isolated or an anode. On impinging on the antikathode the particles of electrified hydrogen diffuse most readily into the weaker parts of the field. A. D.

455. *Magnetic Deflection of Reflected Kathode Rays.* **E. Merritt.** (Phys. Rev. 7. pp. 217–224, 1898.) — Apparatus arranged to observe the behaviour of direct and reflected rays at the same time, and under the same conditions (vacuum, mode of excitation, &c.): the reflected rays being those from platinum. There was no difference between the deflections of the direct and the reflected rays unless the deflecting magnet came so near as to distort the kathode rays between the kathode and the reflector. This would indicate, on the Crookes theory, that the velocity of the particles is not appreciably altered by reflection; and probably the particles are reflected not by the platinum surface as a whole, but by individual particles of platinum. The behaviour of these might be expected to affect the result. A. D.

456. *Kathode and Lenard Rays.* **E. Goldstein.** (Wied. Annalen, 67. 1. pp. 84–94, 1899.)—The author primarily investigates the light of the third kathode layer, called by him K_3 rays.

He first surmised that they were formed by the reflection of the light of the second layer, the K_2 rays. But a further investigation has shown that the K_3 rays proceed in straight lines from every point of the space filled by the K_2 rays. While a solid immersed in K_1 or K_2 rays casts a shadow, it does not do so when immersed in K_3 rays, unless it is broader than the incident K_2 bundle. The well-known fact that kathode rays, when impinging upon a solid substance, give rise to other rays proceeding in all directions as in diffused reflection, is amplified by the author into the statement that these rays give rise to secondary rays both when they impinge upon a solid wall and when they impinge upon gaseous molecules. Hence the origin of the K_3 rays. The latter again appear to undergo a similar process of conversion when impinging upon ponderable matter, but the quaternary rays are very feeble and barely perceptible. When the solid wall is very thin, the incident rays are partly reflected and partly transmitted. The transmitted portion constitutes the Lenard rays.

E. E. F.

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457. *Coherers.* **A. Blondel.** (Écl. Électr. 16. pp. 316–317, 1898.)—The condition of success appears to be that the filings should not be too conductive nor yet coated with too thick a film of oxide. Silver does not work; but if exposed to sulphuretted hydrogen it works better and better up to a certain point, and then as the film of sulphide thickens the efficiency falls off.

A. D.

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458. *Coherer-Sparks.* **R. Malagoli.** (N. Cimento, 8. 4. pp. 109–111, 1898.)—By photographic methods it is found that in the metallic powder coherer the variation of resistance produced by the electric waves is accompanied by sparks from particle to particle of the powder. In order to enable photographic results to be produced the electrodes must be of suitable dimensions. Coherers may be regarded as resonators in which the impact of suitable electric waves reduces the resistance in the dielectric. A. D.

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459. *Velocity of Hertzian Waves in Dielectromagnetic Media.* **V. Boccara** and **A. Gandolfi.** (N. Cimento, 8. 4. pp. 191–215, 1898.)—Media made up of a paste of paraffin and iron powder are both dielectric and have definite magnetic permeabilities. The magnetic permeability μ, the specific inductive capacity K, and the index of refraction for Hertzian waves go on increasing as the proportion of iron is increased. The values of this index of refraction are in concord with the theoretical value $\sqrt{K\mu}$.

A. D.

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460. *"Antennæ" in Wireless Telegraphy.* **A. Blondel.** (Écl. Électr. 16. p. 316 and p. 318, 1898.) The author thinks the action of these depends on their capacity as forming along with the earth a condenser, the seat of an oscillating discharge at the moment when the primary circuit is broken; and the receiving antennæ become the seat of a displacement current which acts on the coherer. **A. Broca** (Écl. Électr. 16. p. 318) notes that the flux of energy (analogous to that in polarised light) passes through zero values, and that it is also along the wire and is indeterminate in direction at the end of the wires in a plane normal to the axis of the antennæ: so that it is concentrated on a particular plane instead of being sent in all directions. The fact that it is polarised tends towards null values as we leave this plane.

A. D.

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461. *Short-circuited Secondary Coil.* **J. H. Smith.** (Phys. Rev. 7. pp. 231–235, 1898.)—The author investigates the effect of a short-circuited secondary coil of small resistance upon the oscillatory discharge of a condenser in the primary circuit. It is shown mathematically that in certain cases the period of oscillation in the primary circuit is diminished, and the result is confirmed by the experiments of Hotchkiss and Millis with the Hotchkiss galvanometer, in which the natural period of the vibration in a circuit is diminished by bringing a solid brass cylinder near the circuit. J. L. H.

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462. *Electric Currents in Dielectric Liquids.* **A. Naccari.** (N. Cimento, 8. 4. pp. 259–260, 1898.)—In dielectric liquids Ohm's law is obeyed, and the specific resistance does not vary with the electromotive force. It was also found that there is no variation of the resistivity with the area of the opposed electrodes.

A. D.

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463. *Dielectric Constants and Temperature.* **H. Pellat** and **P. Sacerdote.** (Comptes Rendus, 127. pp. 544–546, 1898.)—The dielectric constant of paraffin diminishes as the temperature rises; $3\cdot6 \times 10^{-4}$ per °C. between 11° and 22°, and $5\cdot6 \times 10^{-4}$ between 11° and 33°. That of ebonite rises; mean, $8\cdot8 \times 10^{-4}$ between 10°·4 and 20°·6. Consequently, taking previous results (Pellat, Journ. de Physique, 3rd series, vol. 7. p. 18), that to charge a condenser at a constant temperature takes not $CV^2/2$ but $CV^2/2.\{1+T(\lambda+\chi)\}$, where T is the absolute temperature, λ the coefficient of linear dilatation, and χ the variation in the dielectric constant per °C., for an ebonite condenser the term $T(\lambda+\chi)$ has at 27° C. the value 0·29, and the capacity of such a condenser is 29 per cent. greater than has been supposed. If the charging be rapid, it is not isothermal but adiabatic, and

$0{\cdot}29 \times CV^2/2$ ergs of heat are transformed, causing cooling: and on sudden discharge the same quantity is liberated, causing heating of the condenser. For an ebonite condenser of 2 mm., charged to a potential difference corresponding to 1 cm. spark, the heating or cooling would be a little less than $0^\circ{\cdot}001$; but this is masked by the residual phenomena. A. D.

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464. *Dielectric Constant of Stretched Glass.* **G. Ercolini.** (Roma R. Accad. Lincei Atti, 7. pp. 172–177 and 183–189, 1898.)—By the aid of the "principle of the conservation of electricity," Lippmann has shown, theoretically, that, in general, if a dielectric is stretched, the specific inductive capacity when the lines of force run at right angles to the length is increased by an amount proportional to the load. Dessau confirmed Lippmann's conclusion, qualitatively; but Corbino experimenting on glass found that the specific inductive capacity *diminished.* Maxwell stated that the square of the refractive index, under certain conditions, should equal the dielectric constant. Now, when a plate of glass is stretched it behaves exactly like a positive crystal, with the axis parallel to the direction of tension. Moreover, Fresnel noticed that in stretched glass the ordinary index of refraction is less than the original index, and Kerr has proved that the ordinary index diminishes with tension, whilst the extraordinary does not alter, so that Corbino surmises that the dielectric constant ought to diminish in a direction perpendicular to the tension. The author mentions a multitude of reasons why the relationship indicated by Maxwell should have no bearing on the present question; he also criticises Corbino's method of experimenting and states that the experiments lead to no decisive results.

The second part of the author's work contains a description of apparatus and experiments, which show that the dielectric constant of glass is *increased* by tension. A. Gs.

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465. *Electric Properties of Ammonia.* **H. M. Goodwin** and **M. K. Thompson, jun.** (Phys. Rev. 8. pp. 38–48, 1899.)—The dielectric constant of liquid ammonia is determined by Drude's second method. A small condenser containing liquid ammonia at −34° C. is introduced into the secondary circuit of a small condenser, and the length of the circuit for maximum resonance is noted. The same dielectric constant is then produced by mixing benzene with water and acetone. The mean value of the dielectric constant of various specimens of ammonia is 22, being nearly that of ethyl alcohol and of acetone. As regards conductivity, the authors have made determinations for temperatures ranging from −13° C. to −29° C. (under pressure).

At the former temperature it is 1·688, at the latter $1{\cdot}392\times10^4$. The mean temperature coefficient of the conductivity is therefore $0{\cdot}018\times10^4$. The molecular conductivity of silver nitrate dissolved in liquid ammonia is greater than when it is dissolved in water. This points to a high degree of dissociation of the dissolved salt, and that assumption is confirmed by the fact that at high dilutions ($V=100$) the molecular conductivity approaches a limiting value. E. E. F.

466. *Electrolytic Polarisation under Varying Pressures.* **R. Federico.** (N. Cimento, 8. 4. pp. 145–191, 1898.)—At constant pressure, the E.M.F. of polarisation rises rapidly for a short time (about the first second) and then slowly comes up to a maximum value. Apart from the initial rise, the gradual increase is nearly proportional to the time of closure of the circuit; and after about a minute the curve is like a branch of an equilateral hyperbola. The maximum value reached by the E.M.F. of polarisation itself rises with the pressure, more rapidly under low than under high pressures. A. D.

467. *Measurement of Small Inductances.* **H. Martienssen.** (Wied. Annalen, 67. 1. pp. 95–104, 1899.)—The author measures small inductances by the displacements of phase which they produce in an alternate current. He uses an apparatus capable of indicating phase differences down to 1 sec. of arc. It is based upon the following principle: If two branches of a circuit of resistances R_1 and R_2 and inductances L_1 and L_2 are traversed by a sinusoidal alternating current, the numerical phase difference ϕ is given by the equations:—

$$\phi=\phi_1-\phi_2$$

where—

$$\tan\phi^1=\frac{\omega L_1}{R_1}\qquad\tan\phi_2=\frac{\omega L_2}{R_2}$$

and—

$$\omega=\frac{2\pi}{T}=\text{the frequency.}$$

If ϕ is small, this relation holds good for any alternating current whatever, and also—

$$\tan\varphi=\phi=\omega\theta$$

where θ is the phase difference in time. Hence

$$\theta=\frac{L_1}{R_1}-\frac{L_2}{R_2}$$

Hence L_1 can be determined if θ is measured and L_2 is known, or L_2 can be determined by varying R_2.

In the actual apparatus the inductance is measured by the torsion exerted upon a metallic cylinder in a rotary field as a consequence of the phase difference of two currents. The same apparatus can also be used for measuring capacities. E. E. F.

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468. *Magnetic Deflection of Electric Discharge.* **J. Henry.** (Phil. Mag. 46. pp. 429–452, 1898.)—This deflection, by a magnetic force at right angles to the direction of discharge, is like that which a flexible and elastic conducting string would undergo if it carried a current in the same direction as that in which the discharge passes through the gas (J. J. Thomson, "Rec. Res." p. 131, par. 127). By photographic methods the author found the amount of the deflection to vary from gas to gas in the following decreasing order: H; Cl (?); N, O, Air; NO; Br (?); CO; NH_3; CO_2; SO_2 (?). The discharge is also bent or distorted by convection-currents; more so at high than at low gas-pressures: and at very high gas-pressures there is no steady position such as is assumed by the discharge at lower pressures. In hydrogen this distortion was almost imperceptible. There is very little, if any, change of deflection with pressure so long as the current in the discharge is kept constant; the deflection increases with the current in any case, but is independent of the potential-difference. Apparently the discharge follows the lines of least resistance along a chain of ionised particles, which chain is itself deflected: but if the chain or thread be dissipated or destroyed before the next discharge comes, the discharge is then direct, there being no deflection unless each discharge lasts a sensible time. If it do so last, the discharge is broadened, low pressures being necessary in order to bring about this result. The maximum current in the discharge was not at all proportional to the average current: with increasing pressures the former increased, the latter decreased. The quantity of electricity carried by each discharge is of little importance. The kind of gas determines the rate at which the chains or threads of ionised particles are broken up by diffusion so as to tend to make the path of least resistance the shortest one; or by the recombination of the ions; or by the actual travel of the ions towards the electrodes; and it determines the duration of the discharge and also the relative conductivity of the affected path after any given discharge. In mercury vapour (monatomic) the ionising effect of a discharge and the corresponding amount of deflection are small, apparently even less than in hydrogen. Experiments were also made in blowing the discharge in a rarefied gas; the mechanical deflection produced thereby was small in hydrogen, considerable in air; and the magnetic and mechanical deflections are affected by the nature of the gas in exactly the same way. A. D.

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469. *Electrolytes in a Magnetic Field.* **H. Bagard.** (Comptes Rendus, 128. pp. 91–94, 1899.)—While admitting that the specific resistance of electrolytes does not vary in a magnetic field, the author maintains that the resistance of any given liquid conductor is modified by the presence of such a field, and he describes his method of bringing it clearly into evidence. The liquid conductor is a ring of $CuSO_4$ solution contained in a circular glass tube of rectangular cross section. This ring is placed between the poles of an electromagnet so that the lines of force are parallel to the axis of the ring. The latter is interrupted for a short length, and tubes containing more liquid, and serving as terminals, are fused on side by side. On establishing a field of some 5,000 units, the galvanometer indicates an abrupt change of resistance amounting to about 1 per cent. in the case of a ring 4.4 cm. wide, and about 1 sq. cm. in sectional area, and when the current flows in such a direction that the magnetic lines of force would tend to narrow the circle. It is rather more than that when the force is such as would tend, by Ampere's rule, to widen the circle. The author accounts for the effect by supposing that the magnetic field has a definite effect upon the flux of the current in the liquid. E. E. F.

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470. *Magnetic Susceptibility of Liquid Oxygen.* **J. A. Fleming** and **J. Dewar.** (Roy. Soc. Proc. 63. pp. 311–329, 1898.)—The authors describe an investigation of the magnetic behaviour of liquid oxygen under magnetic forces ranging from 500 to 2,500 c.g.s. units. The principle of the method used by the authors is the well-known fact that if a body, either para- or dia-magnetic, be placed in a magnetic field of variable strength, it is subjected to a force acting in the direction in which the field varies most rapidly. The field is provided by a vertical electromagnet, above the upper pole of which is suspended from one arm of a delicate balance a small sphere of a slightly para- or dia-magnetic material. The diameters of the spheres varied from about 1 to about 3 cms., and the materials used were silver, copper, bismuth, and glass. In each case a measurement was made of the magnetic susceptibility in air of the sphere used, by weighing it in a known magnetic field, and observing the loss or gain in weight (the actual field distribution was determined by a ballistic method, using a small exploring coil). The spheres were then weighed when immersed in liquid oxygen contained in a vacuum vessel placed above the pole of the magnet, and the loss in weight was determined when the exciting current was switched on. The mean value of the susceptibility, obtained from 36 determinations, is 324×10^{-6}, and hence the corresponding value of μ is 1·0041. The experiments show clearly that the susceptibility tends to decrease somewhat in strong fields. A comparison of the above value of the susceptibility with that of gaseous oxygen ($0{\cdot}13 \times 10^{-6}$) confirms the view that the susceptibility varies directly as the density and inversely as the absolute temperature. A. H.

471. *Magnetic Susceptibilities.* **E. Seckelson.** (Wied. Annalen, 67. 1. pp. 37–68, 1899.)—The magnetic susceptibilities of iron, cobalt, nickel, manganese, and platinum were examined by Quincke's method, in which a straight wire of the metal is hung by a bifilar suspension, and one of its ends is introduced between the poles of an electromagnet. That end is attracted into the field with a force depending in a certain manner upon the susceptibility of the material, and the consequent displacement of the other end is read by means of a microscope. The author examined electro deposits of the metals named on copper wires, and found that for all directions of the lines of force the susceptibility is greatest in iron, and that the other metals follow in the succession cobalt, nickel, manganese, and platinum. He also found that the susceptibility normal to the magnetic lines of force does not vary with the field, but that it diminishes in increasing fields parallel to the lines of force. The former susceptibility falls with increasing sectional area, the latter does the same after first passing through a maximum. The magnetic force across the lines of force increases as the square of the field. With the stronger fields the force along the lines of force increases simply as the field. E. E. F.

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472. *Fall of Magnetisation in Soft Iron.* **Lagrange.** (Paris, Soc. Franç. Phys. Bull. 118. p. 1, 1898.)—Displacement of fluorescent spot in a Crookes tube arranged in an electromagnetic field; when the electromagnet-exciting current is shut off the spot begins to return to its previous position, at first rapidly, then more and more slowly. The form of the curve of return is studied by means of a rotating mirror. A. D.

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473. *Eddy Currents and Hysteresis.* **A. Grau.** (Wien Akad. Sitzber. 107. pp. 495–505, 1898.)—The loss of energy through eddy currents in a mass of iron is ascertained, and by subtracting this as well as the amount dissipated through heating according to Joule's formula, from the total loss, the amount of work dissipated in hysteresis is obtained. The iron used was formed into rings of the same mass and of diameters 1, 2, and 3 mm., which were made the cores of transformers wound with copper wire through which an alternating current was sent. J. J. S.

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474. *Magnetic and Geodetic Observations in Madagascar.* **P. Colin.** (Comptes Rendus, 127. pp. 708–711, 1898.)—The author has determined the difference in longitude between a number of places in Madagascar by means of telegraphic signals,

also the latitude. Determinations of the three magnetic elements were made at three stations and gave the following results :—

Station.	Date.	Lat., S.	Long. E. of Paris.	Height above sea level.	Dec., W.	Dip.	Horizontal force.
Ankazobé ..	Aug. 8, 1897	18° 19′ 29″	44° 45′ 25″	1243 m	11° 32′ 10″	54° 2′ 35″	0·21146
Andriba ..	Aug. 22, 1897	17° 34′ 34″	44° 32′ 30″	653 m	11° 9′ 42″	52° 20′ 19″	0·20547
Vohilena ..	Sept. 12, 1897	18° 8′ 1″	45° 15′ 23″	1329 m	10° 40′ 12″	53° 39′ 58″	0·21307

W. W.

475. *Magnetic Charts.* **E. Mathias.** (Journ. de Physique, 7. pp. 455–461, 1898.)—The author proposes, at any rate for magnetic charts of comparatively small portions of the earth's surface, to represent the *difference* between the magnetic element at the different points on the chart and its value at some fixed magnetic observatory within the district, instead of the actual values of the element. The advantage claimed for this method is that the secular change of such differences is much smaller than the secular change of the elements itself, so that the chart can be used for a number of years with less chance of error, the values at the place considered being obtained by adding the quantity given by the chart to the value of the element for the time considered as obtained at the observatory. W. W.

476. *Magnetic Elements on Jan.* 1, 1899. **T. Moureaux.** (Comptes Rendus, 128. pp. 94–95, 1899.)—The magnetic elements are given for Parc Saint-Maur, Perpignan, and Nice. For Parc Saint-Maur, situated at Long. 0° 9′ 23″ E Paris and Lat. 48° 48′ 34″ N, they are the following :—

	Absolute Values Jan. 1, 1899.	Secular Variation during 1898.
Declination	14° 51·45′	−4·60′
Dip	64° 57·5′	−1·4′
Horizontal force	0·19682	+0·00022
Vertical force	0·42127	+0·00002
Total force	0·46498	+0·0011

The values for Jan. 1st are the means of all the hourly values for Dec. 31st and Jan. 1st. E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

477. *Free Hydrogen in Atmospheric Air.* **A. Gautier.** (Comptes Rendus, 127. pp. 693–694, 1898.)—Atmospheric air contains minute quantities of combustible carbonaceous gases, derived from the earth or from combustion. The air of mountains or of the sea is nearly free from them, but always contains a small but very constant amount of hydrogen, from 11 to 18 c.c. per 100 litres being found. T. E.

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478. *Diffusion through Ferrocyanide Membranes.* **A. Naccari.** (N. Cimento, 8. 4. pp. 260–261, 1898.)—For a given membrane, the substances blocked by it have higher molecular weights than those which pass through. Generally (aniline being an exception) the lower the molecular weight the higher the velocity of passage, but the product of the $(\text{velocity})^2$ into the molecular weight is not constant; for the velocities at low molecular weights are proportionately higher than this would indicate. A. D.

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479. *Cryoscopic Solvents.* **F. Garelli.** (Roma R. Accad. Lincei Atti, 7. 2. pp. 27–34, 1898.)—The author recommends the use of stannic bromide as a solvent for solid solutions, and gives detailed results of its use with $C_2H_4Br_2$, $C_2H_4Cl_2$, $CHBr_3$, CBr_4, &c. A. D.

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480. *Osmotic Pressure in Ether Solutions.* **H. M. Goodwin and G. K. Burgess.** (Phys. Rev. 7. pp. 171–187, 1898.)—The authors describe measurements of the vapour pressure of ethereal solutions of naphthalene, benzophenone, and diphenylamine. The osmotic pressures of the dissolved substances are calculated and substituted for the pressure in the gas formula $PV = RT$. Tables are given of the product PV. The conclusions are: The osmotic pressures of solutions of naphthalene, benzophenone, and diphenylamine in ether at 12°·90C at concentrations varying from 0·01 to 1·0 normal, indicate that none of these substances in solution behave like perfect gases, but like readily compressible gases, as the values of PV decrease with increasing concentration. This decrease is very marked in the case of benzophenone and less so with naphthalene; in the case of diphenylamine, the product diminishes up to 18 atmospheres, when it becomes constant or possibly increases. Azobenzene, on the other hand, investigated by Noyes and Abbot, very nearly approaches to the condition of a perfect gas. "It would seem very probable, that every substance when in solution has its own

characteristic condition equation connecting temperature, osmotic pressure and volume, analogous to every more or less compressible gas even when complications arising from ionisation or polymerisation phenomena are, from the nature of the solvent and solute used, highly improbable. Substances analogous to the permanent gases would seem to be the exception rather than the rule." S. S.

481. *Transference-Value of Hydrogen.* **W. D. Bancroft.** (Journ. Phys. Chem. 2. pp. 496–497, 1898.)—MacIntosh's conclusion that the Helmholtz method of determining transference numbers is not applicable to gas cells, is controverted, the variation in determinations of these numbers being pointed out. B. B. T.

482. *Variance of the Voltaic Cell.* **W. D. Bancroft.** (Journ. Phys. Chem. 2. pp. 427–440, 1898.)—A critique of Nernst's application of the phase-rule to the Clark cell, and a general consideration of the factors causing variability of E.M.F. of cells, and of the use of Le Chatelier's theorem to predict the sense in which the E.M.F. changes. B. B. T.

483. *Three-Component System.* **J. F. Snell.** (Journ. Phys. Chem. 2. pp. 457–491, 1898.)—The solubility of potassium chloride in aqueous acetone is determined at various temperatures, and the composition of mixtures which separate in two liquid layers. The behaviour of various other salts is determined qualitatively. B. B. T.

484. *Three-Component System.* **N. Dodge** and **L. C. Graton.** (Journ. Phys. Chem. 2. pp. 498–501, 1898.)—The temperatures at which two liquid layers are formed by aqueous ethyl alcohol in presence of excess of potassium nitrate are determined. B. B. T.

485. *Mixtures of Isomorphous Bodies.* **G. Bruni.** (Roma R. Accad. Lincei Atti, 7. 2. pp. 138–145, 1898.)—Both with regard to the temperatures of congelation and with regard to the distribution of the components between the liquid and solidified portions of the whole, mixtures of isomorphous substances completely follow van't Hoff's theory of solid solutions. A. D.

486. *Equilibrium of Two- or Three-Component Systems.* **G. Bruni.** (Roma R. Accad. Lincei Atti, 7. pp. 198–205, 1898.)—Where the components neither mix nor are isomorphous, there is complete parallelism between binary and ternary systems as regards their equilibrium; only in the latter there is always the third component in its solid phase. Where two of the components make a stable addition-compound, there is again complete parallelism with the same addition. Where two of the components make an unstable addition-compound, the result is analogous to the preceding at lower temperatures. Where two of the components are isomorphous, there is again complete parallelism with the same addition. Accordingly, if to a system of two components, with one possible liquid phase only, there be added a third component which does not combine with the former two, nor yet is isomorphous with them, the curves showing equilibriums of the same order (saturation curves in binary systems and curves of cryohydratic character in ternary systems) have a parallel course. Only, in the systems represented by the curve of the ternary mixture there always appears in addition, in solid phase, the third component added. A. D.

487. *Equilibrium of Stereoisomers.* **F. K. Cameron.** (Journ. Phys. Chem. 2. pp. 409–416, 1898.)—Benzaldoxime is studied in the manner of Carveth's investigation of acetaldoxime (see 1898, Abstract No. 826). B. B. T.

488. *Electrolytic Production of Crystallised Tungsten.* **L. A. Hallopeau.** (Comptes Rendus, 127. pp. 755–756, 1898.)—Lithium paratungstate, fused at about 1000° C., is electrolysed using platinum electrodes. After extraction of the mass with water, hydrochloric acid, and a solution of lithia, a residue of crystalline tungsten remains, which contains up to 6 per cent. of platinum derived from the electrodes. Iron electrodes are rapidly attacked by the fused salt. T. E.

489. *Organic Electro-Chemistry.* **M. Krüger.** (Elektrochem. Ztschr. 5. pp. 98–105, 1898.)—This is a continuation of the author's previous historical papers (see 1898, Science Abstracts No. 1185) and relates to the action of electrolytic oxygen, chlorine, bromine, and iodine upon various organic compounds.

W. G. M.

490. *Electro-Metallurgy.* **S. Cowper-Coles.** Eng. Mag. 15. pp. 594–602, 1898.)—This illustrated article deals with the following application of electrolytic methods in connection with the deposition or use of metals. I. Electro-galvanising. A

description of the author's frequently described process, with plans of an electrogalvanising plant. II. Electrolytic-pickling. (see 1898, Abstract No. 688.) III. The manufacture of parabolic reflectors. (See 1898, Abstract No. 545.) IV. The use of copper or tin as protective coatings for ironwork. An account of the methods used for coating the Dome of the Philadelphia City Hall, taken from the Electrical World for April 16, 1898. V. The use of brass as a protective coating for ironwork. Details of a method of depositing brass electrolytically from a cyanide solution of the two metals copper and zinc, using a sheet-brass anode. VI. Tin scrap recovery. A description of the two methods in which sodium hydrate and sulphuric acid are used as electrolyte respectively. (See 1898, Abstract No. 842.) VII. White lead manufacture. A description of six of the numerous patented electrolytic processes for the production of white lead. Only one of these is stated to be at work on an industrial scale. In this thin sheets of corrugated lead are packed between layers of coke or carbon, and strips of tin are used to make electrical contact between the lead and carbon. The remainder of the process is the customary Dutch process, but owing to the electrochemical action set up by the contact between the carbon and lead, the time necessary to convert the lead into carbonate is reduced by two-thirds. J. B. C. K.

491. *Electrolysis of Alkali Chlorides.* **F. Winteler.** (Zeitschr. Elektrochem. 5. pp. 10–15, 49–51, and 217–221, 1898.)—A critical account is given of some of the chief facts and theories concerning the electrolytic production from alkali chlorides of (1) chlorine and caustic alkali, (2) hypochlorites, (3) chlorates and perchlorates. In the first and third sections, which form the greater part of the paper, the author treats of the choice of electrodes and diaphragms, and describes some experiments on the electrolysis of potassium chloride solutions, in which analyses were made of the anode and kathode fluids and also of the gases evolved. The bearing of the results obtained on the prevention of secondary reactions and on the conditions for economical working is discussed. N. L.

GENERAL ELECTRICAL ENGINEERING.

492. *Electrical Steering-gear.* **J. Fischer-Hinnen.** (Écl. Électr. 16, pp. 531–536, 1898.)—This article describes the arrangements devised by Giles (see La Lumière Électrique, xlix. p. 81, 1893), and Pfatischer (see 1898, Abstract 312), for this purpose. A number of diagrams are given and the theory of the two methods worked out. C. K. F.

493. *Continuous Beams.* **H. J. Tomlinson** and **K. Pearson.** (Phil. Mag. 46. pp. 306–311, 1898.)—In a paper published in the Royal Society Proceedings, vol. lxii. p. 268, 1898, G. Wilson develops a novel method of finding the reactions at the points of support of continuous beams, which affords an easy solution for continuous beam problems, including those due to alterations in the levels of the supports. Wilson applies his method to a particular example by numerical calculation. In the present paper the authors show how the same problem can be treated graphically, a good draughtsman being able to complete the work indicated in 6 to 8 hours. The method is fully described and a sheet of reduced drawings is appended. A. S.

494. *Direct-Reading Engine Power Gauge.* **G. F. Atwood.** (Elect. Engin. N.Y. 26. pp. 300–302, 1898, and Engng. News, p. 245, 1898.)—The function of this instrument is to continuously measure and give a direct indication of the mean effective pressure on the piston of an engine, without the necessity of taking indicator diagrams. The working principle of the instrument is the measurement of the steam pressure by the speed of a steam turbine, having sufficient inertia to make its speed constant for successive impulses of the motor. A tachometer is driven by the turbine motor, and this motor in turn is driven by steam from the cylinder of the engine through two pairs of nozzles connected to opposite ends of the cylinder. The indicating mechanism acts as a load on the motor; it consists of a fan attached direct to the turbine shaft, and adapted to drive a second fan mounted on a delicately pivoted shaft, having an indicated hand and being controlled by a spring. The angular deflection of the pointer is proportional to the speed of the turbine.

The paper in Engineering News gives many illustrations of the details of the instrument. A. S.

495. *Engines for Electric Railway Power Stations.* **C. E. Emery.** (Street Rly. Journ. 14. pp. 244–261, 1898.)—This paper is a continuation of previous articles (see 1898, Abstract

No. 724), which describe the largest engines of the Corliss type. The present paper concludes the series and gives further examples of such engines, together with a number of high-speed engines which are provided with valve-gear adapted also for medium speeds. The special constructive features of each engine are fully described and illustrated. A. S.

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496. *Carbon Dioxide Motor.* (Frank. Instit. Journ. 146. p. 156, 1898.)—At a meeting of the Franklin Institute, W. F. Roberts described and exhibited in operation his carbon dioxide engine, which has three cylinders, each 2" bore and 2" stroke. The vertical engine measures 14 × 10 × 18". The claim is made that the engine is capable of running at 2,000 revs. per minute, under a pressure of 1,500 lbs. per sq. in., cutting off at $\frac{1}{64}$". Under these conditions the engine develops 25 H.P. The total weight is 85 lbs. The engine is supplied with gas from steel cylinders containing liquid carbon dioxide which is heated in passing through a copper coil on its way to the engine. A. S.

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497. *Cleaning Water-Tube Boilers.* (Street Rly. Rev. 8. pp. 754–755, 1898.)—A description of a turbine water boiler cleaner made by the Chicago Boiler Cleaning Company. The tool comprises a turbine enclosed in a case $2\frac{5}{8}$" diameter and 3" long. To the turbine shaft the cleaner is connected by a universal joint which allows the tool to pass through curved tubes. The turbine revolves at about 2,000 revs. per minute. The arms of the cleaner are thrown out by centrifugal force, and the scale when cut away is washed out by the stream of water from the turbine. Eight tons of scale were so removed from five boilers in the power house of the Cleveland City Railway Company. A. S.

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498. *Coal-Handling Machinery.* (Street Rly. Rev. 8. pp. 721–723, 1898.)—The California Avenue station supplies current for the Chicago tramways. In the boiler-room there are ten water-tube boilers of 300 H.P. each. The coal storage house is a separate building 24 ft. wide by 200 ft. long. The coal is delivered in waggons, weighed on a platform scale, dumped into a hopper, reduced to fairly uniform size in a crushing machine, conveyed either into the coal storage house or into the bin in the boiler-room, and is fed from the bin to the stoker by chutes. A conveyer collects the ashes from below the boiler and deposits them in a bin outside the building. Descriptions are given of the coal-handling plant of the Toronto Railway Company, and of the power house of the Chicago City Railway at 49th Street and Oakley Avenue. At the latter power house the cost of handling

the fuel from the time it enters the yard to the time it goes out in the form of ashes is 16 cents per ton, and it is estimated that the saving effected pays 20 per cent. per annum on the capital invested in the machinery. A. S.

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499. *Calorific Power of Weathered Coals.* **R. S. Hale** and **H. J. Williams.** (Street Rly. Rev. 8. pp. 885–886, 1898.)—This paper was read before the American Society of Mechanical Engineers. Samples of Maryland, Virginia, Pennsylvania, and Ohio coals were collected. For tests of fine coal, the samples were ground and thoroughly mixed; for tests of lump coal, samples were broken into lumps of nut size. One set of samples was exposed on an uncovered balcony for eleven months; the method of exposure closely reproducing the conditions of the surface of a pile of coal left in the open. The samples were all analysed by H. J. Williams, and the results are given in tabular form. The conclusions to be drawn from the results are: (1) That weathering decreases by about 2 per cent. the theoretical calorific power, as calculated by Dulong's formula; (2) that weathering decreases by about one-half of 1 per cent. the actual calorific power, as shown by the bomb calorimeter; (3) that when it is desired to compare the respective calorific powers of weathered coals and of coals that have not been exposed, the use of Dulong's formulæ or of Kent's curve would lead to erroneous conclusions. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

500. *Induction Generators.* **M. Leblanc.** (Comptes Rendus, 127. pp. 813–817, 1898.)—The author showed, in 1890, that if $2p$ denote the number of poles of an induction motor, ω its angular velocity, and n the frequency of the exciting current, then the machine acted as a motor so long as $\omega < \frac{n}{p}$, but that in order to make $\omega > \frac{n}{p}$, power had to be spent in driving the machine, energy being furnished to the polyphase circuit. In 1892 the author applied this property of induction machines to secure stability in the synchronous running of alternators, by surrounding the polar expansions with closed circuits consisting of heavy bars of copper. A machine so constructed may be regarded as a combination of an alternator with an induction motor, the armature of the alternator acting as a field-magnet towards the induced circuits on the pole-pieces. If the angular velocity ω should become $> \frac{n}{p}$, the induction machine immediately acts as a brake; on the other hand, if ω should momentarily become $< \frac{n}{p}$, the induction machine develops a driving-torque. The author states that this device has proved thoroughly satisfactory in practice. He next considers the practicability of employing an induction machine as a generator. This would do away with the necessity of synchronising it before connection to the supply mains. A description is given of an induction generator, with a special form of exciter. The winding is so arranged that although a large air gap is used the effects of magnetic leakage are neutralised. A. H.

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501. *Running Shunt Dynamos in Parallel.* **A. Philip.** (Electrician, 42. pp. 161–162, 1898.)—The considerations and the experiments dealt with by the author in this article are based on the recent breakdown at Brighton. Special precautions have to be taken when shunt machines of different design are run in parallel. The speeds and resistance in the shunts are adjusted, so that, as nearly as possible, the electromotive forces of all the machines may rise and fall in the same ratio when the load on the bars varies. If the load increases the consequent drop in the electromotive force developed in the armature must be the same. This means that either the machines shall be of identical design, or that if of different types the resistances in their shunts and their speeds shall be so adjusted that they shall all work at about the same magnetic induction in their field-magnets. If the

adjustment has not been made very well a very large increase of load may cause the distribution of load to vary so greatly that a motoring of one or more of the machines might occur—that is, the load might be entirely removed from them and converted into a negative one. The greater the alteration of the 'bus-bar pressure, the greater is the danger that this accident may occur. If the machines whose loads are thus lightened are furnished with minimum current cut-outs they will not motor, but will be removed from the bars. A sudden drop in voltage on the 'bus bars may occur (1) by decreasing the resistance between the 'bus bars, as, for instance, by a short circuit of the bars; (2) possibly by the breaking of a shunt circuit, even when the armature had been removed from the bars; (3) by a short circuit in the armature windings of one of the machines; (4) by suddenly switching out one of the dynamos when giving some considerable fraction of the total current. The behaviour of the dynamos under these different conditions is fully discussed.

In the case of a dead short circuit of the 'bus bars, if the armatures do not burn out, they will run round the lower limb of the dynamo characteristic curve and cease to give any current at all, or if provided with minimum current cut-outs these will take them off the bars. If, however, one or more of the machines are working with their field-magnets excited to a flatter position of the BH curve than the others, then these will take most of the load, and the remaining machines will be cut out by their minimum current cut-outs; whilst, finally, the machines thus left on the bars will cut out with their excess current fuses, or failing this they will run round the lower limb of the characteristic curve and give zero current.

The fact that at Brighton the main fuses on two of the machines are said to have remained intact whilst the machines were still on the bars appears to render the supposition that the breakdown was due to a dead short across the bars somewhat improbable. The author suggests that the breaking of a circuit from 'bus bar to 'bus bar which has large self-induction, and carrying a large current (such as the shunt coil of a machine), might cause a marked fall of pressure. He is, however, unable to definitely state that this would occur, as he has not had the opportunity of making the test on a sufficiently large scale.

With regard to the third contingency it is supposed that the armature is short-circuited by some accident from brush to brush, outside the brushes but inside the minimum cut-out. The current in the armature would then suddenly increase enormously, and as the brushes here lead there would be a sudden weakening of the magnetic strength of the shunt field, and consequently a sudden rise of E.M.F across it in the same direction as would be the case if it were broken. In fact, the armature would act like the primary of a step-up transformer, of which the shunt windings form the secondary. The E.M.F thus set up in the shunt would act so as to lower the potential across the main, or even possibly reverse it. It should also increase the armature currents of the machines still remaining in parallel, and weaken their shunt circuits. In order to test the magnitude of this effect the author performed an experiment, which he describes fully in the article.

Lastly, the sudden removing of the armature from circuit by means of the minimum cut-out would of itself cause a drop in the bars, and the two effects added together may account for the large similar type dynamos (if they were working on a less saturated field than the two smaller ones) cutting out and finally leaving the other two alone on the bars.

It may be added that even if all the dynamos in parallel have precisely similar armature reactions, and are all working on the same portion of the magnetisation curve, yet a *sudden* fall of pressure on the bars may cause those machines whose shunt windings have the smaller time constants to drop their electromotive forces more rapidly than those machines whose shunts have larger time constants; and if this was the case at Brighton, one would expect that the shunt coils of two smaller machines had larger time constants than the larger machines whose minimum current cut-outs acted. L. J. S.

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502. *Multiphase Armature Windings.* **J. P. Stone.** (Amer. Electn. 10. pp. 456–458, 1898.)—The author describes, with diagrams, bar windings for multiphase armatures. Wave winding has many advantages over lap winding. When there are two bars in each slot, all the top bars at one end have their ends bent in one direction, and all the bottom bars in the opposite direction, and as each bar spans half the distance between the slots, the two ends which come directly over each other are joined by a clip. Any continuous current winding can be used for alternating work, but the reverse is not true. R. B. R.

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503. *Armature Windings.* **A. L. Rice.** (Amer. Electn. 10. pp. 501–502, 1898.)—The author describes a four pole parallel wound drum-armature with three distinct circuits on it, that is to say, each conductor carries one-twelfth of the whole current. This he calls a four pole, four circuit armature, with triple telescope winding. He also describes a two pole gramme armature with two circuits, and apparently calls this a telescope winding also. R. B. R.

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504. *Walker Railway Motor.* (Amer. Electn. 10. p. 181, 1898.)—The author illustrates and describes an 80 H.P. Walker motor to be used on the Brooklyn Elevated Railway. The frame of the motors is made entirely of cast steel, the magnetic ring being circular in form and containing four laminated field-magnets with pole shoes. Each one of the magnets is wound

with bar copper, insulated with asbestos, forming a perfect fireproof coil.

The armature is hollow and provided with air ducts running radially through the laminations to ensure perfect ventilation. The winding is made from bar copper, with only one turn for each commutator bar. The modern practice of very few slots is used for the armature, with four inductors in each slot, the insulation being entirely of mica, rendering it also fireproof. The frame of the motor is left practically open for complete ventilation, so that the heated air on the interior of the motor can escape freely, thereby increasing the capacity for the motor for sudden and heavy over-loads. The motor is so designed that it will not spark under any condition of load, and can take currents two or three times the normal current of the motor with good efficiency and without damage to any part of the machine. The current density in the commutator brushes is about 35 amperes per square inch. L. J. S.

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505. *Combined Transformer and Rectifier for Polyphase Currents.* **J. Sahulka.** (Zeitschr. Elektrotechn. Wien, 16. pp. 405–409, 429–431, 1898.) — This paper describes two methods of rectifying polyphase currents without the use of a motor-generator. The first of these is due to Hutin and Leblanc (German Patent, No. 78825) and consists in that the secondary windings of the stationary transformer serving for the transformation of the high-tension polyphase currents, are each formed of two systems of oppositely wound coils which are connected together and with the segments of a collector on which slide two brushes moved by a small synchronous alternate-current motor, the current for which can be taken from one of the systems of coils. A continuous current of more or less uniform strength can be taken from these brushes.

The secondary coils, in the examples given, are of even number—*e.g.*, eight—and for a monophase-current primary are arranged side by side along the core, so that the first half of them—*e.g.*, the first four—are wound in an opposite direction to the last half—*e.g.*, the last four—and the whole of these secondary coils are connected up in series in a closed circuit, so that, if a current were passed through this circuit, the brushes being out of contact with the collector, their resultant magnetising effect would be zero. The connections between the adjacent coils are connected to the segments of the commutator, so that, as the brushes (which are arranged diametrically opposite each other) slide on the commutator, the secondary coils supply a rectified current to the continuous-current-circuit, which pulsates between zero (when equal numbers of oppositely wound coils are in series with each other) and a maximum value (when the two sets of oppositely wound coils are in parallel with each other).

To reduce the speed of the brush-holder, the motor can be made multipolar, at the same time increasing the number of collector-segments, *e.g.*, if the motor have eight poles, the number of segments must be four times that of the number of coils in the secondary circuit; each four segments 90° apart are connected, and the brushes are 45° apart. The pulsations of the rectified current can be reduced by inserting a coil having self-induction into the circuit.

In order to obviate the use of a coil having self-induction, two-phase or multiphase alternating currents must be employed. These can be converted into low tension currents by single transformers, or by a combined multiphase-current transformer. All the secondary circuits must consist of two systems of coils arranged as above mentioned. For two alternate-currents having a difference of phase of 90°, the currents magnetise separate cores which each have, say 12, secondary coils in two oppositely wound groups. The E.M.F. induced in one group of coils on core I may be indicated by E. sin α, that induced in one group of coils on core II by E. cos α; the phase of the latter being a quarter-period in advance. Since in the present case the rotation of the brushes on the collector during a quarter-period corresponds to the space of three coils, the coils of the two secondary circuits should be connected together so that each coil of core I is in series with a coil of core II, the number of which is three higher, the coils of core I being connected to the commutator as described in connection with the monophase arrangement. In this arrangement, the E.M.F. in the continuous current circuit varies ±14·7 per cent. By making some of the coils on each of the cores, say, Nos. 6, 7, 1, 12, with only ⅓ the number of turns as the others, the pulsation may be reduced to ±2·22 per cent.

With triphase currents three cores are employed, each with, say, 12 coils as before. Since a difference of phase of 120° corresponds here to a space of four coils, coil 1 of core I is to be connected in series with coil 5 of core II and this with coil 9 of core III which is connected to coil 2 of core I, and so on. The coils of core I are connected to the commutator as before. This arrangement, with like coils, gives a pulsation ±7·18 per cent.; with coils 6 and 12 on each core omitted, but the connections to commutator otherwise the same, the pulsation is ±0·52 per cent. Diagrams of various arrangements are given together with a plan of an actual apparatus for triphase currents. This process can also be used for converting continuous currents into polyphase currents.

In the other class of apparatus the action is as follows, taking as an example the apparatus designed by Zipernowsky and Déri (Ger. Pat., No. 51596), where separate coils are employed for the several polyphase currents and for the continuous current, viz.: A rotary magnetic field is produced by the polyphase currents in a stationary Gramme-ring- or drum-armature; the ring or drum winding is connected with the segments of a stationary collector on which slide brushes which are rotated by means of a synchronously running armature, and from these brushes a continuous current can be taken.

Several of these transformers are illustrated; the author objects to this latter form of apparatus, on the ground that it must necessarily be as expensive to construct as the ordinary motor-generator converters and makes the following suggestions:—

1. The device for taking off the rectified current should not be arranged on the transformer itself, but separately, as is the case in the Hutin and Leblanc transformer; the transformer thus need only have bi-polar winding, whilst the small motor which turns the current-collecting device alone need have multipolar winding.

2. Since the transformer itself can comprise no rotating part, the ring or drum form of armature can be relinquished, and very simple forms of frame can be employed, so that the apparatus may be of the ordinary alternate-current transformer form; by this arrangement also the resistance of the magnetic circuit can be very much reduced.

Several forms of apparatus embodying these suggestions are described and illustrated. C. K. F.

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506. *Rotary Converters.* **E. de Marchena.** (Ind. Élect. 7. pp. 329–331, 354–356, and 378–382, 1898.)—This is a lengthy mathematical discussion of rotary converters which is difficult to abstract. The following are some of the conclusions arrived at:—

1. There is no advantage in compounding alternators for feeding rotary converters. Alternators with considerable self-induction are suitable for the purpose and will give a minimum wattless current on a line with variable load.

2. When an alternator is compounded to give a constant potential difference between its terminals for all loads, or, when a converter is connected between constant potential mains, the resistance and self-induction of the transformers and the line will not in general be sufficient, and to avoid excessive currents an inductance must be placed in series with the converter.

3. There is no advantage in determining the excitation of the converter for unit power factor for full load. It is preferable to annul the wattless currents for a less value of the load, say for 70 or 80 per cent. of full load.

These results have been obtained on the assumption that power absorbed by the converter when running light may be neglected. W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

507. *Tests of Traction Plant.* **G. W. Munro.** (Street Rly. Rev. 8. pp. 728–730, 1898.)—Purdue University students tested the 750 H.P. plant at La Fayette, and give curves of current used during the working of the road and the output and efficiency at different times of the day. Owing to unfavourable load-factor, the boilers, which were tested with coal and with natural gas, showed a very low rate of evaporation. A ton of coal was equivalent to only 13,560 cubic feet of gas at atmospheric pressure and 62° F., instead of the usual 30,000 cubic feet. The exhaust steam heater furnished 13·6 per cent. of the heat given to the water without perceptibly increasing the back pressure. The running expenses using gas, were 1·11 cent per kw. hour output, and 1·65 cent per car mile: using coal, these figures were respectively 1·73 cent and 2·5 cents. E. H. C.-H.

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508. *Test of Power Station.* (Street Rly. Rev. 8. pp. 875–878, 1898.)—Elaborate tests extending over forty-five hours with twenty-four observers were made at the Harvard Station of the Boston Elevated Railway Company. There are six Babcock boilers having a total capacity of 3,000 H.P. The chimney-stack 16 feet diameter, is 226 feet high, and the flue contains a 560-tube Green economiser. The three main E. P. Allis engines have cylinders 28 and 56 by 60 in., and are cross-compound, jet-condensing, rated at 1,800 H.P. each, and 150 lbs. pressure. Their 24-feet fly-wheels each weigh 60 tons. They are direct-coupled to 12-pole 1,200 kw. generators at 80 R.P.M. Some of the chief resultsare :—

Equivalent evaporation from and at 212° F. per lb. dry coal (boilers and economiser)	10·68 lbs.
Percentage of total heat contributed by economiser	7·62
Steam per hr. per I.H.P. of main engines	14·05 to 15·13 lbs.
Coal ,, ,, ,,	1·47 to 1·56 lbs.
Condensing water per hr. per I.H.P. of main engines	344 to 432 lbs.
Efficiency (E.H.P. to I.H.P.)	88·8 to 90·9 %
E.H.P. to run feed pumps	13·4 to 15·3

E. H. C.-H.

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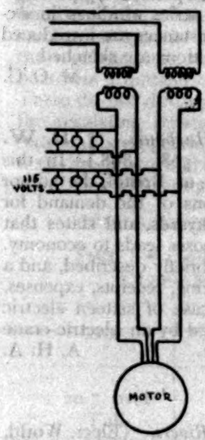
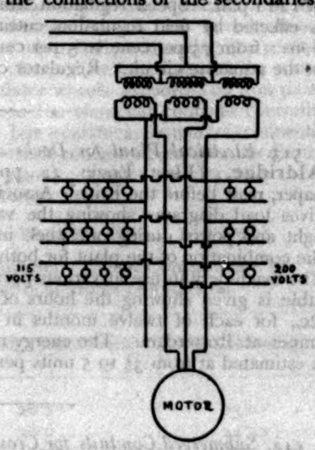
509. *Multiphase Systems for Central Station Service.* **W. S. Kelley.** (Elect. Engin. N.Y. 26. pp. 281–284, 1898.)—It is well known that a multiphase system is preferable to a single alternating circuit only when a satisfactory combined lighting and *power* service is required at all points of the distributing network. The only multiphase systems which have to be practically considered are the two-phase and three-phase systems. For two reasons the interlinked or three-wire two-phase system has not proved a

success: (1) on account of the higher P.D. which exists between the outer mains; (2) because of the unbalancing which takes place, even with an equally distributed load, on account of inductance. Comparing the two-phase with the three-phase system for a combined lighting and power service, the author arrives at the following results:—

		Number of Wires.	Weight.
Primary Network...	2-phase	4	4
	3-phase	3	3
Secondary Network	2-phase	4	100
	3-phase	4	29¼

The two systems are illustrated in the accompanying diagrams. It will be seen that in the case of the three-phase four-wire secondary network, a slight change in the connections of the secondaries, either at the transformers or at a centre of distribution reached by the four secondary wires, the voltage across the wires can be quickly changed from 115 to 200. With regard to the question of balance, advantages have been claimed for the two-phase system, but recent practice has shown that in this respect also the three-phase system is superior. The author concludes that the three-phase system has decided advantages, in every respect, over the two-phase one. A. H.





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510. *Economy in Small Electric Light Stations.* **E. P. Roberts.** (Elect. Engin. N.Y. 216. pp. 292–293, 1898.)—These articles contain a careful examination of all points connected with power stations in which economies may usually be effected, and indicate the best methods of estimating the pecuniary results of the alterations suggested. M. G. W.

511. *U.S. Electric Lighting Company's Station at Washington.* **N. M. Hopkins.** (Elect. Engin. N.Y. 26. pp. 425–433, 1898.)—Contains a detailed account of the new power station with photos of the plant, &c. The new power installed is about 4,800 H.P. M. G. W.

512. *Electricity in Printing.* **G. A. Damon.** (Elect. World, 32. pp. 499–504, 1898.) The more notable parts of the power plant are a steel chimney unstayed 125 ft. high by 54 in. diameter; Corliss valves with engine speed 125 r.p.m.; armatures with hollow shafts direct driven and so aligned that either engine can drive any or all of the dynamos by a shaft through the hollow armature. The 40 presses are direct-coupled to motors at 120 r.p.m. Speed regulation from full speed to 75 per cent. is effected by field regulation, cutting in series windings in sections: from 75 per cent. to 5 per cent. resistances are introduced in the armature circuit. Regulator connections are sketched. M. O.'G.

513. *Electrical Plant for Docks and Harbours.* **J. D. W. Aldridge.** (Elect. Engin. 22. pp. 565–568, 1898.)—In this paper, read before the British Association, at Bristol, the author gives load diagrams showing the variations of the demand for light and power during one week in dockyards, and states that the combination of the plant for both purposes leads to economy. The machinery in use at various ports is briefly described, and a table is given showing the hours of working, receipts, expenses, &c., for each of twelve months in the case of sixteen electric cranes at Rotterdam. The energy required by an electric crane is estimated at from 3½ to 5 units per hour. A. H. A.

514. *Submerged Conduits for Crossing Rivers.* (Elect. World, 32. pp. 442–443, 1898.)—Cables drawn into waterproof conduits are preferable to armoured cables for crossing rivers; two such conduits are in use at Boston, U.S.A. One of these consists of seven wrought-iron pipes, each 4 inches in diameter, enclosed in a wooden shell 4 inches thick and 24 inches in external diameter; the wooden pipe is built up in sections from 1½ to 6 feet long. The whole is of the form of the letter U, and is lowered into a trench in the bed of the river. The other conduit consists entirely of wood, having twenty-four ducts, and is built up of seven layers, each 6 inches thick, in sections 4 feet to 20 feet long; the complete conduit weighs 40 tons. Lead-covered cables are drawn into the ducts in both instances. A. H. A.

515. *Belfast Electric Supply Works.* (Electrician, 41. pp. 837–845, 1898.)—This is an account of the Belfast Electric Supply Works, and is interesting on account of the use of gas for motive power. Although the use of gas power is said to work satisfactorily, a supplementary station is being erected in which steam engines will be used. The equipment of the engine-house consists of three sets of continuous-current steam dynamos, the steam engines being built by G. E. Belliss & Co., and the dynamos by Thomas Parker. A fourth set is in course of erection. Two of the Belliss-Parker sets consist each of a Belliss engine placed between two 50-kilowatt balancing dynamos direct-coupled on one shaft. The larger set consists of a single three-crank engine, coupled direct to a 200-kilowatt continuous-current dynamo, capable of delivering from 440 to 500 volts. The table given below shows tests of these engines and dynamos. A novel feature of the switching arrangements is the introduction of mechanical gear in place of electrically connecting the wires for the regulating resistances. Immediately in front of the switchboard are a number of regulator wheels, supported on iron pillars. These do not directly actuate the electrical contacts controlling the regulating resistances, but operate a system of connecting rods and bevel gearing, by which contact-pieces, at some distance from the board and in a place of greater security than on the board, are efficiently controlled.

TRIALS OF BELLISS-PARKER STEAM DYNAMOS.

TEST I.—100-Kilowatt Set.—Steam Consumption in Pounds per Electrical Horse-power Hour.

Load.	Condensing (pounds steam).	Non-Condensing.
20 % over	20·27	23·0
Full	20·6	24·32
¾	21·02	26·9
½	21·37	31·53
¼	22·74	40·99

TEST II.—200-Kilowatt Set.

20 % over	22·0	24·9
Full	22·0	26·1
¾	23·3	28·5
½	25·1	33·3
¼	26·2	44·1

W. G R.

516. *Snoqualmie Falls Transmission Plant.* (West. Electn. 23. pp. 99–100, 1898.)—This is an account of the three-phase plant which is being installed at Snoqualmie Falls to provide power for the cities of Scattle and Tacoma. The total water power available throughout the year is 30,000 H.P. The alternating current will be generated at 1,000 volts and transformed up for transmission at 25,000 or 28,000 volts. The line wire will be of aluminium, No. 2 and No. 3 B and S gauge. The estimated cost of the plant is $500,000. W. G. R.

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517. *Liverpool Electric Tramways.* (Electrician, 42. pp. 99–104, 1898.)—This is the first example of municipal electric light and traction systems being combined under one roof. At present 6½ miles of track have been experimentally equipped on the trolley system, partly with centre poles and partly with span wires. Two trolley wires of 0·4 in. diameter run centrally over the tracks throughout. Two 0·4 sq. in. feeders are used, laid on Callender's solid system in iron troughs. The Board of Trade pilot cables are contained in 3-core 7/18 conductors, lead-covered and armoured, two of the cores being used as a series telephone circuit 17,200 yds. long, the conductor forming a continuous loop, into which the instruments can be inserted at the feeder pillars and a few other points. Car sheds for 50 cars with small repair shops are nearly completed. The German and American types of car are being tried. The former are of the pattern used at Hamburg on rigid trucks with two 20-H.P. Schukert motors. They hold 20 passengers; similar trailers hold 18. The American cars have Brill maximum traction trucks and Walker equipments. One car is fitted with a standard air-brake actuating the same blocks as the hand-brakes. The air-pump is worked off the axle. All the cars have electric emergency brakes. The generating plant comprises three non-condensing Willans-Siemens 300-H.P. generators, to which will be added similar 1,500-H.P. sets. There is no fly-wheel to the latter sets, the necessary weight being located in the armature. There are also 246 E.P.S. cells with 21 plates, giving a maximum of 480 amperes at 550 volts for one hour. The tramway switchboard consists of three panels. The main panel contains d.p. switches and s.p. fuses for the generators and the cells; also a circuit breaker and two meters, one working in either direction on the battery circuit, which also passes through a recording ammeter. The capacity of all the switches is 300 amperes, but the circuit breaker is set normally at 500 amperes and potentially at 800. The booster panel contains two s.p. throw-over switches for connecting the line-feeder and track-feeder to the 'bus bars direct or through the booster. The Board of Trade panel contains two low-reading recording voltmeters, one recording ammeter reading to 10 amperes, and an ammeter with two scales

of 0·0005 to 0·005 and 0·05 to 5 amperes. The booster will consist of three E.C.C. machines rigidly coupled in line. The centre machine is a 500-volt shunt motor, the outside machines being series-wound generators giving a potential at any speed proportionate to the current, up to a maximum of 300 amperes, and having their magnet coils in series with one of their armatures.

The total cost of the construction and equipment of the 6½ miles of tramway in this experimental line is estimated at £82,000, viz., £33,000 for the line construction and equipment, £24,000 for the total of 45 cars, and £25,000 for the car sheds and workshops. E. H. C.-H.

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518. *Chicago Elevated Electric Railroad.* (Electrician, 42. pp. 110–114, 1898.)—Illustrations show the power station and third rail construction at a cross-over track. The power house, which is compactly placed under, and between, the up and down lines of the 4-track way, contains two 2,500-H.P. and two 1,200-H.P. units. Condensing water for the vertical compound engines is brought from and returned to the river, a mile away. Of the General Electric generators, the smaller have 10 poles and carry 18 ft. fly-wheels weighing 45 tons, and running at 75 r.p.m., while the larger machines have 12 poles and 25 ft. fly-wheels weighing 70 tons each and running at 100 r.p.m. The twelve Babcock boilers have Babcock stokers chain driven by two oscillating engines. The chimney shaft is 150 ft. high by 12 ft. 6 in. internal diameter and is supplemented by two large centrifugal fans. The 90-lb. track rails are each bonded at their centres to the steel structure. The third rail consists of 45-lb. channel iron elevated slightly above the timber safety guards and carried either on one or the other side of the track according to the position of the points, &c. At intervals of 5 ft. the third rail is carried on square blocks of pine saturated with paraffin wax and resting on iron pedestals.

The 40-passenger motor cars haul one or two trailers, have cabs at each end, and are carried on independent bogeys, each equipped with a 100-H.P. motor of the G.E. 2,000 type. The cab at one end contains a 3-H.P. motor for working the air-pump for the brakes. On both sides of the car there is a front and back shoe carried on stiff springs. Each motor truck is inspected every three days. E. H. C.-H.

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519. *Electric Tramways in South Africa.* (Street Rly. Journ. 14. pp. 211–215, 1898.)—The Cape Town and Port Elizabeth tramway systems are described, these having been equipped on American methods. The Cape Town line has a length of 22 miles of single track, with a maximum grade of 7 per cent., and a minimum curve radius of 38 ft. The Port Elizabeth line is 10½

miles long, divided into 4½ miles of double track and 2 miles of single track. The maximum grade is 1 in 8·55.

The trolley wire is No. O B and S gauge. Part of the feeders are underground and part overhead. The average drop allowed on the feeders is 5 per cent., with a maximum of 10 per cent. The drop on the return circuit is limited to 7 volts.

L. J. S.

520. *Union Traction Company of Philadelphia.* (Street Rly. Journ. 14. pp. 691–700, 1898.)—The above company operates, through consolidations and by leases, about 450 miles of track in the city of Philadelphia and its suburbs, and earns nearly $11,000,000 gross. It is the largest street railway property in the world.

The arrangement of staff and the expenses and profits of the system are stated in this article. The company now operates its lines from seven main power stations, and three sub-stations, while three stations have been abandoned. The location of these stations is shown on a map, and the character of their equipment is shown in a table.

The dynamos for the main station were manufactured by the Westinghouse Electric and Manufacturing Co.; there are four machines of 1,500 kw. each. The field has 14 poles built up of laminated steel and cast in the yoke. At the pole tips the corners of half the laminations are cut away, leaving but half the pole section at the edges, but with full section at the centre. The proportions of the corners are such that the field distortion with load is comparatively small, and the strengthening of the magnetic field due to the series coils is principally at the commutating pole-tip. The series and shunt coils are separately wound and insulated, and have an air space between them when in position on the field. This prevents the conduction of heat from one to the other. The armature is 128 in. in diameter, of the slotted type, with bar windings, and is parallel wound. The coils are made of copper strip bent into the exact shape, and insulated before placing on the coils. The construction of the armature core is such as to dispense with bolts for clamping the core or end plates. A characteristic feature of the armatures of these machines is the balanced condition of the magnetic circuits. By special construction, the magnetic strengths of the different field poles are kept equal, independent of inequalities in the magnetic circuits. By this means the parallel wound armature is able to give equal E.M.F.'s on all its fourteen circuits under any conditions. A field coil may be short circuited or even reversed, and the machine will continue to operate well. The armature may be out of centre without producing any appreciable effect on the commutation or undue magnetic drag. The weights of the different parts of the dynamo are given. The arrangement of switchboard is fully described. Great care is taken to keep the lead sheathing of the cable always negative, so as to prevent electrolysis, and an inspector is constantly making tests all over the system to accomplish this result. L. J. S.

521. *Chicago Elevated Railway.* **J. R. Cravath.** (Elect. Engin. N.Y. 26. pp. 368–369, 1898.)—Curves are given showing the effect produced by introducing a storage battery to meet the fluctuations on this line. W. R. C.

522. *Johnson-Lundell Surface Contact System.* **E. H. Johnson.** (Elect. Engin. N.Y. 26. pp. 516–518, 1898.)—The author remarks that American Street Railway Companies do not desire the success of any system of traction other than the trolley, as, by their leases, they can be compelled to adopt any practicable system. He then refers to the past history of surface contact systems, and finally states that the cheapness of the Johnson-Lundell electro-magnetic system justifies its adoption wherever the overhead trolley is now a financial success. The switches, of which details are given, are made up complete in the factory in cases ready to be placed in the outer boxes supported between the track sleepers. E. H. C.-H.

523. *Murphy Third Rail System.* (Street Rly. Journ. 14. p. 231, 1898.)—The article describes and illustrates a new system of sectional third rail, due to S. M. Murphy. The method consists essentially in exciting the section of third rail over which the car is about to pass by electromagnetic means, and cutting the section out of circuit automatically after the car has passed. Every car carries upon it, under the seats, a 10-cell storage battery, giving about 20 volts. The batteries are employed only when the car is starting, and then only to make the necessary connection between the feeder supply and the third rail section over which the car is standing. To do this they drive a rotary converter which produces 500 volts at its generator end, exciting an electromagnetic switch which automatically connects the section on which the car is standing, and the one immediately in front of it, with the main source of supply. The 500-volt current is then admitted to the motor, and the car proceeds as in ordinary practice. After starting, the rotary converter operates in the opposite way, charging the battery until it is again needed. The electromagnetic switch cuts out the sections after the car passes, rendering them dead. The chief feature of the system lies in the construction of the switch, which is the critical point of a system of this kind. The important point of the switch lies in the method of preventing arcs, which is effected by employing a secondary and independent fine wire winding which is short

circuited on itself by means of carbon contacts, when the thick wire or active coil is opened, and which is itself finally opened after the latter operation. Both circuits are opened by means of carbon brakes.

Full details are given of the form of shoe contact employed. The article describes further a method of carrying the motor on the car which is also applicable to the trolley system and to all types of motors. Roller bearings are introduced at the axle bearing of the motor, greatly reducing the friction at this point. The system is equally applicable to surface or elevated roads, and can be installed while the cars are in operation by any other power without interfering with traffic. L. J. S.

524. *Comparative Costs of Cable, Electric, and Horse Traction in New York.* (Street Rly. Journ. 14 pp. 721–724, 1898.)—This article, for the first time in the history of street railroading, gives a true comparison of the relative cost of operation of cable, electric, and horse railways in a single city and under substantially the same conditions by a company controlling the local transportation of over 250,000,000 passengers per annum. On broad principles the company's experience points unmistakably to the great superiority of electricity over both horses and cable, not only in traffic handling capacity, but in economy.

On January 1, 1893, the entire street railway system of New York City was operated by horses. The importance of doing away with horse traction, in the interests of both the city and the company, became so great, however, that it was at last determined to try the underground conduit electric system, which had previously been a failure in America wherever installed, owing partly to climatic conditions and partly to an attempt to use too shallow and cheap a conduit. From the first experiments onwards the conduit system proved a thorough success.

The annual and quarterly reports included in this article show that during the twelve months' period the company operated 34·2 per cent. of its car mileage by the cable system, 20·2 per cent. by the electric system, and 45·6 per cent. by horses. During the last quarter, however, the proportions were greatly changed, the cable mileage being only 27·2 per cent. of the total, the horse 33·7 per cent., while the electric had risen to 39·1 per cent.

The relative traffic densities, measured by the receipts per mile of track and per car mile as shown in the quarter's report, are as follows: cable, $39,000 per mile of track and $·333 per car mile; electric, $17,000 per mile of track and $·260 per car mile; and horse, $8,000 per mile of track and $·288 per car mile. The average earning power of the entire system was about $14,000 per mile of track and $·29 per car mile. These figures per track mile are for the quarter only. Another gauge of traffic density is found in the statement that the 11 per cent. of the company's entire mileage which is operated by the cable system is earning 28 per cent. of the total passenger receipts; the 28 per cent. which is operated by the electric system is earning 32 per cent. of the total passenger receipts; and the 61 per cent. which is operated by horses is earning but 30 per cent. of the total passenger receipts.

For the year, the operating expenses of the cable lines were 16·42 cents per car mile, of the horse lines 17·87 cents, and of the electric lines 10·23 cents. For a three months' period offering more favourable circumstances for electric traction the cable lines cost 17·55 cents, the horse, 17·89 cents, and the electric 10·06 cents. The electric lines during the twelve months' period earned 16·76 cents net per car mile, or but 1·25 cents less than the cable system, in spite of the fact that the latter has 7·43 cents per car mile greater receipts, while for the three months' period the net earnings of the electric lines per car mile were actually greater than the cable lines by ·25 cents, and greater than those of the horse lines by 5·04 cents.

It overturns all established ideas to find that two temporary electric power stations can actually produce power for heavy electric cars 22 to 28 feet in length at a cost less by 30 per cent. (in the quarterly statement) than can be done in two cable power stations which operate cables so heavily loaded as to make the proportion of live to dead weight greater probably than that of any cable railway system in America, except with the possible exception of the State Street line of the Chicago City Railway Company. In the transportation expenses we find again that electric traction is the cheapest of the three motive powers, and the reason for this is found chiefly in the greater speeds of car possible with electric traction, which increases the service divisor. In the quarterly statement it is seen that in every grand division of operating expenses electricity has a decided advantage over the cable system, and in every division except maintenance of equipment it has an advantage over the horse system.

During the twelve months' period the cable lines operated at 47·7 per cent. of their passenger receipts, the electric lines at 37·9 per cent., the horse lines at 65·3 per cent., and the entire system at 53·3 per cent. During the three months' period the cable lines operated at 52·7 per cent. of their passenger receipts, the electric lines at 38·6 per cent., the horse lines at 62·1 per cent., and the entire system at 50·9 per cent. It should not be hastily assumed from the above statements that the conduit system could be adopted with financial or engineering success by street railway companies in general. New York City and Washington, which have the only electric conduit roads of any size found in America, are peculiarly favoured in the matter of climate and cleanliness of streets, the rainfall and snowfall during the year being extremely small. L. J. S.

525. *Comparative Traction Costs.* **W. A. Harding.** (Street Rly. Rev. 8. pp. 906–907, 1898.)—In a paper on Practical Points in Street Railway Engineering the author quotes the following figures from a report of the President of the Metropolitan Street Railway of New York:—

Expenses of operating horse cars 17·87 cents, cable cars 16·42 cents, and electric cars 10·23 cents per mile. E. H. C.-H.

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526. *Rail-Bonding in Brooklyn.* **R. P. Brown** and **G. E. Chapin.** (Elect. World, 32. pp. 311-312, 1898.)—Report of the Committee on Bonding, presented to the N.Y. State Street Rly. Assoc., September, 1898. In 1895 it was decided to replace the old rails, which carried practically no current, by well bonded 9 in. girder rails. After removing scale from under the base of the rail by a portable emery wheel, a cast copper plate was clamped by iron plates to the ends of the rails, covering 12 sq. in. on each rail and in contact up to within ¾ in. of the end of the rail, whence the metal was curved to allow for expansion. Attempts made to seal these bonds watertight with non-hardening pitch were unsuccessful; nevertheless, recent tests show that rust has not yet affected their resistance. This method was not more costly than the use of $\frac{4}{0}$ bonds, but required close supervision, to obviate which an electrically brazed bond was adopted in 1896, and is now the standard. It is now placed on the base and upper flange of the rail outside the fishplate, and consists of a dozen leaves of soft copper $\frac{1}{64}$ in. thick, the carrying portion being ¾ in. wide, and the brazed contact being 1 sq. in. in area. Soft spelter and a flux are used in brazing. For flexibility the bond is divided longitudinally into three parts; its length between centres of contacts is 5 in., and its equivalent section is 350,000 mils.; all rails are double bonded. Owing to absence of a portable brazing apparatus, the bonds were made in two parts and brazed on in the yard, the ends being interlaced, riveted, and soldered when the rails were in place. Consequently some of the branch lines could not wait for brazed bonds, and were bonded with horseshoe bonds, 3½ in. long, placed under the fishplates. Any irregularities in the holes, due to drilling at maker's and subsequent reaming out with emery paper, are filled up if care is used in compressing the terminals, whose diameter is ¾ in. Special work is better bonded outside the fishplates. Straight track is cross-bonded every 750 ft. by copper wire connected to a brazed terminal having 6 sq. in. of contact. These terminals are bolted to the rails to prevent mechanical strain on the joints. The Falk cast welded joints make the best possible electrical connection. Joints are tested by taking simultaneous readings with two Weston millivoltmeters, one across the joint, and the other across 2 ft. of solid rail.

The following results have been obtained :—

	Drop per foot		Relative Conductivity (Solid Steel=100).	
	of rail.	of joint.	30 ft. rail.	60 ft. rail.
Falk joint	·00215	·00355	98	99
Double brazed bond	·00725	.00758	99·8	99·9
Johnson bond	·00364	·00342	95·6	97·8
Plate bond............	·0109 (2 ft.)	·0233 (6 in.)	89	94

Six hundred amperes can safely be carried by any of the bonds mentioned, and the cost of double bonding should not exceed 3s. per joint, 90 per cent. of the conductivity of solid steel being readily obtainable. It is therefore cheaper to make the return wholly of well bonded steel rails, supplementing the track near the power houses with worn-out rails carefully bonded.

E .H. C.-H.

527. *Diagonal Rail-Bonding.* (Street Rly. Rev. 8. p. 766, 1898.)—The Harrington Rail-Bonding Co. obtain a large surface for bonds by drilling the holes diagonally where the web and bottom flange meet. With a special drilling machine, the two holes may be drilled, reamed, and the bonds put in place in two minutes. The reamer tapers ¼ in. per foot, and the "Columbia Protected" bonds are coned to the same taper. E. H. C.-H.

528. *Cars for Special Purposes.* (Street Rly. Journ. 14. pp. 704–707, 1898.)—The Nassau Company of Brooklyn have a special car fitted with hydraulic jack, by which the car can be lifted off the rails at a crossing and put on to another track having no connection through points. Also a special tower-car with adjustable platform on roof, enabling repairs to be affected on the "up" trolley wire while the tower-car is on the "down" line. With this car it is possible to string up live trolley wire at the rate of one mile in twenty minutes. E. H. C.-H.

529. *New Controller.* **J. C. Henry.** (Street Rly. Journ. 14. pp. 433–434, 1898.)—The author appears to separately excite the motors by putting the fields direct on the line, regulation being effected by varying the fields. By so doing, the capacity of the motors is increased. In the usual way about 60 per cent. of the total energy used by the cars is absorbed in getting them under headway. But by the author's method a great deal of this is

saved, no resistance being inserted in the armature circuit; and a further saving of energy is effected by using the motors, which automatically become dynamos, for braking the cars. The method has the further advantage that, as the field is controlled by the line pressure, the speed of the car remains about the same on all parts of the track. In changing from series to parallel, one of the armatures is short-circuited with a resistance. Reversing is effected by the fields. W. R. C.

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530. *Wear of Steel Rails.* **A. T. Moxham.** (Elect. Engin. N.Y. 26. pp. 459–460, 1898.)—Experiments lasting for three years have been made on a "soft" and on a "hard" steel rail, and on a rail both "hard" and "ductile" supplied by the West End Street Railway Company of Boston. Thirty-three rails in all were laid continuously in the South Eighth Street tracks of the Nassau Electric Railroad, Brooklyn. The cars pass this point at extremely short intervals. The percentages of carbon in the soft, hard, and West End rails were 0·280, 0·590, and 0·570 respectively. The specific gravities were 7·956, 7·971, and 7·977 respectively. The tensile strengths were 75,860 lbs., 118,100 lbs., and 120,380 lbs. respectively. The average monthly wears were 0·0017, 0·0012, and 0·0007 inches respectively. On this basis the time taken to wear away ½ in. would be 25 years, 35 years, and 60 years respectively for the soft, hard, and West End rails. The author emphasises the fact that unless the joints be made perfect, there is no need to worry about the quality of the steel; the very cheapest steel that can be bought will last longer than the joints will allow the rails to be kept in the track. A. S.

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531. *Electricity on Torpedo Vessels.* **B. Pontifex.** (Elect. Engin. 22. pp. 455–457, 1898.)—In this paper the features peculiar to the electric lighting of small war-vessels are briefly described and discussed. A. H. A.

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532. *Ship-wiring.* **J. C. Bagot.** (Elect. Engin. 22. pp. 454–455, 1898.) — The author briefly describes the ruling conditions and the methods adopted in installing the electric light on board merchant ships. A. H. A.

533. *Duflos Arc-Lamp*. (Ind. Élect. 7. pp. 387–388, 1898.)—In this lamp the two carbon-holders are connected by a chain passing over and gearing with a sprocket pinion mounted on an arbor which also bears a large gear-wheel. About the same axis as the gear-wheel there oscillates a frame having two arms. In one of these arms there is pivoted an arbor which bears a pinion gearing with the above-mentioned gear-wheel and also a ratchet- or detent-wheel having long teeth adapted to be brought into and out of engagement with a fixed finger or tooth by the oscillation of the frame. The motion of the said frame is controlled by connecting its other arm, by means of a link, to a pivoted lever bearing the laminated core of the controlling electromagnet (shunt), and also a weight for counterbalancing the moving system. When the magnet attracts its armature, the ratchet- or detent-wheel is moved away from the stop-finger and the carbons are brought together; when the circuit through the carbons is completed, the shunt magnet releases its core and the detent-wheel moves back into engagement with the stop-finger and strikes the arc. By reason of the length of the teeth of the detent-wheel, the stop-finger can enter more or less deeply into the spaces between them, and thus a fine feed is obtained.

C. K. F.

TELEGRAPHY AND TELEPHONY.

534. *Hertzian Telegraphy.* **E. Ducretet.** (Comptes Rendus, 127. pp. 713–716, 1898.)—The author describes the "coherer" system of telegraphy in use since last October between the Eiffel Tower and the Paris Panthéon—a distance of 4 km. The transmitter is the usual form of oscillator, excited by an induction-coil giving a 25 cm. spark. This sparking-distance is diminished considerably when the exploring-wire is connected to the apparatus; the author attributes the diminution to the great capacity of the exploring-wire—the wire is not very far from the metal-work of the tower. The receiver is contained in a portable box at the Panthéon, and means are provided for registering the signals. It is worth noting that although this system works perfectly arranged in this way, it fails when the attempt is made to interchange the sending and receiving apparatus at the two stations, *i.e.*, it fails when the Eiffel Tower is made the receiving station for signals sent from the Panthéon. The case is an extreme one, owing to the large masses of iron and other conducting material in the vicinity. R. A.

535. *Telephone Distances exceeding the K.R. Law.* **A. E Dobbs.** (Elect. Engin. N.Y. 26. pp. 406–407, 1898.)—The K.R. law does not allow for the good effects of leakage and self-induction, and whereas it states that speech will be indistinct if K.R. exceeds 50,000, the line Boston to Omaha has K.R. =400,000 with clear speech. The test for capacity is taken with open lines, whereas the capacity is in effect reduced by bridging bells. In long lines the disturbances from want of balance tend to counteract each other. A lightning arrester is illustrated. M. O'G.

536. *Telephone Switchboard at Harlem, N.Y.* (Elect. Engin. N.Y. 26. pp. 512–513, 1898.)—Glow-lamp signals worked by relays give great simplicity. Subscribers have no transmitter battery or magneto. Unhooking a receiver glows a lamp at the exchange and saves time on the ringing method. When the operator plugs into the answering jack the lamp goes out. As long as both subscribers keep their receivers unhooked both lamps are out. When both "hang up" both lamps light, thereby giving a disconnection signal, and the operator need never listen in to know if a conversation is ended. A trunk line uses a red lamp and two white ones. The whole system is admirable from the point of view of supervision. M. O'G.